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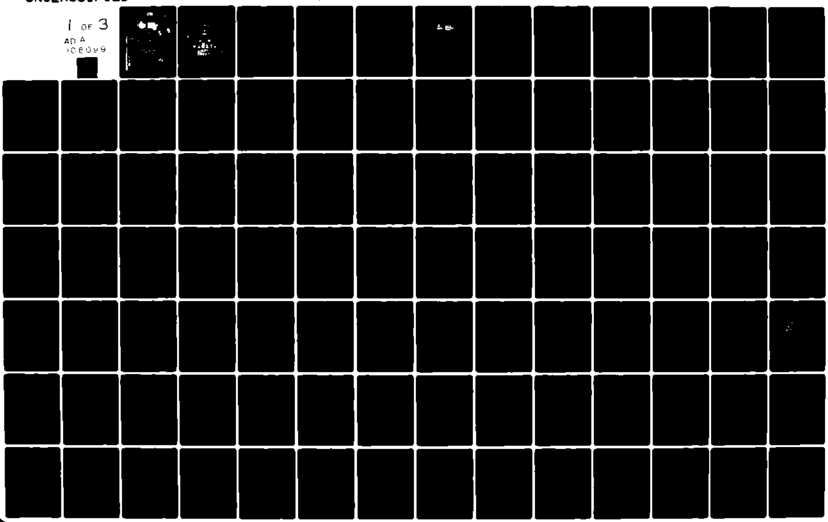

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FINAL REPORT

REVIEW OF NATIONAL DEFENSE, EMERGENCY AND SAFETY ISSUES AFFECTING THE WATERWAYS

PREPARED FOR:

U.S. ARMY CORPS OF ENGINEERS
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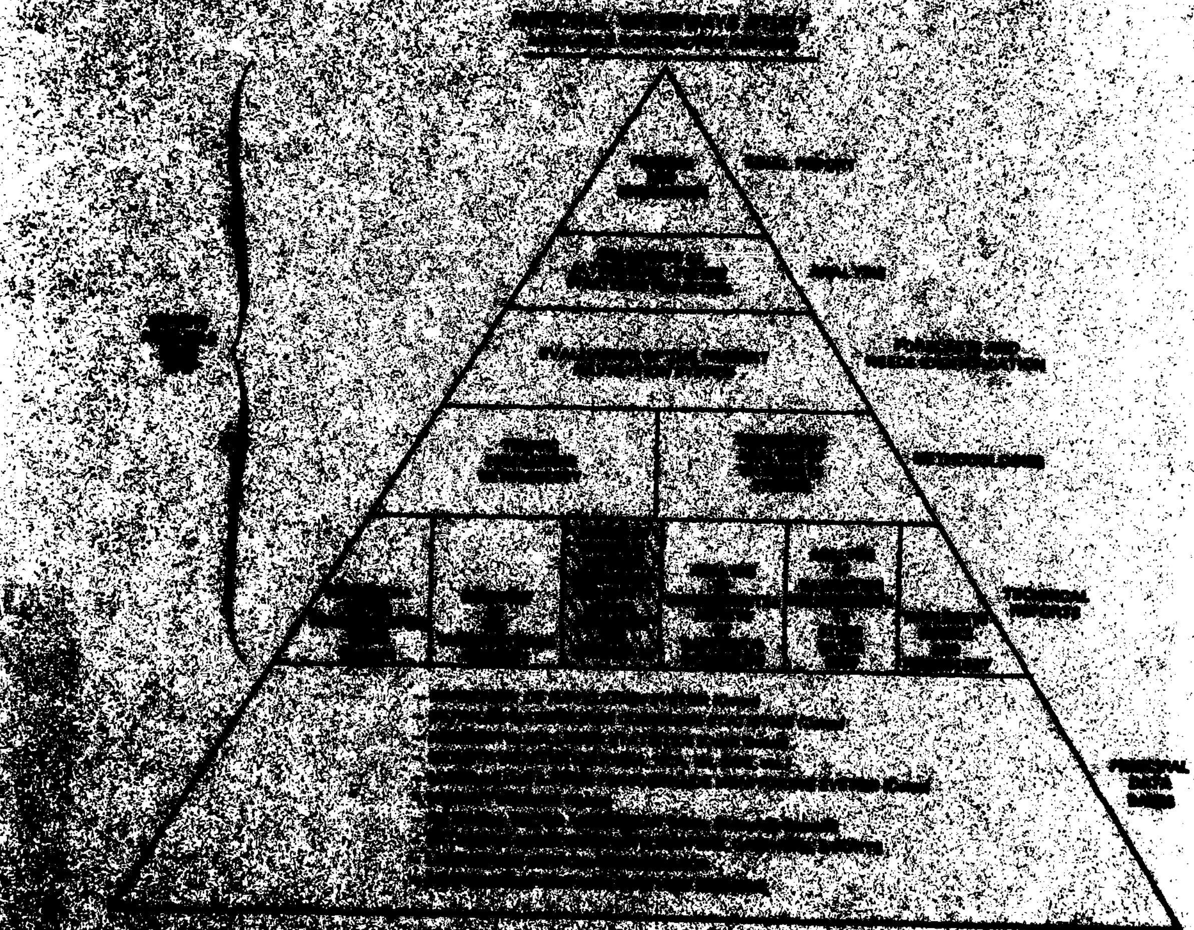

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This report of the National Waterways Study focuses on certain transportation issues relevant to the development of national waterways system strategies. Three major topics are addressed in the report: 1) National defense roles of the waterways system historically, currently and as envisioned for future contingencies; 2) Waterways system requirements during non-defense emergency situations; 3) Waterways system safety, restricted to casualties involving vessels and the associated damages.

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THIS REPORT IS PART OF THE NATIONAL WATERWAYS STUDY AUTHORIZED BY CONGRESS IN SECTION 158 OF THE WATER RESOURCES DEVELOPMENT ACT OF 1976 (PUBLIC LAW 94-587). THE STUDY WAS CONDUCTED BY THE US ARMY ENGINEER INSTITUTE FOR WATER RESOURCES FOR THE CHIEF OF ENGINEERS ACTING FOR THE SECRETARY OF THE ARMY.

NATIONAL WATERWAYS STUDY

REVIEW OF NATIONAL DEFENSE, EMERGENCY AND SAFETY ISSUES AFFECTING THE WATERWAYS

PREFACE

This report is one of eleven technical reports provided to the Corps of Engineers in support of the National Waterways Study by A. T. Kearney, Inc. and its subcontractors. This set of reports contains all significant findings and conclusions from the contractor effort over more than two years.

A. T. Kearney, Inc. (Management Consultants) was the prime contractor to the Institute for Water Resources of the U. S. Army Corps of Engineers for the National Waterways Study. Kearney was supported by two subcontractors: Data Resources, Inc. (economics and forecasting) and Louis Berger & Associates (waterway and environmental engineering.

The purpose of the contractor effort has been to professionally and evenhandedly analyze potential alternative strategies for the management of the nation's waterways through the year 2000. The purpose of the National Waterways Study is to provide the basis for policy recommendations by the Secretary of the Army and for the formulation of national waterways policy by Congress.

This report forms part of the base of technical research conducted for this study. The focus of this report is analyze defense, emergency and safety issues relevant to the development of national waterways system strategies. The results of this analysis were reviewed at public meetings held throughout the country. Comments and suggestions from the public were incorporated.

This is a deliverable under Contract DACW 72-79-C-0003. It represents the output to satisfy the requirements for the deliverable in the Statement of Work. This report constitutes the single requirement of this Project Element, completed by A. T. Kearney, Inc. and its primary subcontractors, Data Resources, Inc. and Louis Berger and Associates, Inc. The primary technical work on this report was the responsibility of A. T. Kearney, Inc. This document supercedes all deliverable working papers. This report is the sole official deliverable available for use under this Project Element.

FINAL REPORT

REVIEW OF NATIONAL DEFENSE, EMERGENCY AND SAFETY ISSUES AFFECTING THE WATERWAYS

PREPARED FOR

U.S. ARMY CORPS OF ENGINEERS
INSTITUTE FOR WATER RESOURCES
WATER RESOURCES SUPPORT CENTER
KINGMAN BUILDING
FORT BELVOIR, VA 22060

UNDER CONTRACT NUMBER
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AUGUST 1981

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EXECUTIVE SUMMARY

PURPOSE

Research conducted within Element E/F of the National Waterways Study addresses a specific mandate to review "...the existing system and its capabilities for meeting the national needs, including emergency and defense requirements." This report focuses on certain transportation issues relevant to the development of national waterways system strategies which would otherwise be diffused throughout other NWS elements.

Three major topics are addressed in this report:

1. National defense roles of the waterways system historically, currently, and as envisioned for future contingencies. Demands on the waterways system derived from industrial, agricultural and energy production during a future major military contingency are addressed as part of Element K2/L, Capabilities and Alternatives.

2. Waterways system requirements during non-defense emergency situations.

3. Waterways system safety, restricted to casualties involving vessels and the associated damages and injuries evolving from such incidents. Casualties refer to accidents where either the vessel or its cargo is damaged, or to a vessel grounding, whether or not any damage occurs. Personnel deaths or injuries during normal vessel operations are excluded. Included are issues associated with the transport of hazardous materials.

Research conducted within Element E/F was primarily a review of published reports, magazine and newspaper articles, federal regulations, and Congressional documents on subjects related to the three topic areas. Additional information was obtained through telephone and personal interviews with people in government, private industry and trade associations. Data on Department of Defense fuel movements was provided by the Defense Fuel Supply Center. Additionally, the United States Coast Guard provided a

magnetic tape copy of their vessel casualty recorder for fiscal years (FY) 1977 and 1978 which was analyzed by the National Waterways Study team.

The objective was to summarize from existing work those issues related to the three topic areas which should be considered in the development of waterways system strategies. Development of new information or analysis techniques was beyond the scope of Element E/F.

The basic findings and conclusions of the analysis conducted under Element E/F are summarized in the sections which follow.

NATIONAL DEFENSE ROLE OF THE WATERWAYS SYSTEM

National defense requirements for the waterways system have remained much the same throughout the Twentieth Century. Those were found to be as described below. Each type of waterway has its own set of requirements. The priority of those requirements within the type of waterway are:

1. Shallow-draft inland rivers: transport commodities associated with the aluminum, steel, and other strategic industries; continue to support the general industrial, agricultural, and energy production base; relieve overloads on other transport modes when possible; transport military items on an as-needed basis.

2. Shallow-draft intracoastal waters: transport fuel to military bases; meet the same requirements noted for inland rivers.

3. The Great Lakes: transport commodities associated with the steel and other strategic industries; provide a merchant and naval shipbuilding capability; continue to support the general industrial, agricultural, and energy production base; transport fuel to military bases; provide a secondary port capability for ocean shipping.

4. Deep-draft coastal channels: provide access to commercial and military terminals used for the deployment of military units and resupply cargo; provide access to naval operating bases and shipyards; transport fuel to military bases; receive imports of strategic materials; continue to support the general industrial, agricultural, and energy production industries.

These requirements can be met by a waterways system strategy which provides adequate maintenance of those waterways important to the national defense. Although such waterways are usually those which already transport significant volumes of commercial traffic or serve large naval bases, there are a few channels where the Department of Defense is the dominant user. A prime example is Port Mahon, Delaware, which is a shallow-draft terminal that provides fuel to Dover Air Force Base, the East Coast base for the C-5A transports.

Planning for a minimum federally-owned dredging fleet should recognize additional national defense requirements not incorporated to date, such as shallow-draft coastal waterways and naval base access. Budgeting should provide adequate funds to maintain waterways important to the national defense.

During a national defense emergency, allocation of civilian transportation resources will be conducted by the Department of Transportation. Likewise, water resource allocation will be conducted by the Department of the Interior. The general process of allocating resources based upon claims from other federal agencies presents serious questions in terms of responsiveness to demands. Conflicts between resource departments, such as Transportation and Interior, will require resolution by the Federal Emergency Management Agency. Further, emergency authorities for management and control of the waterways system have been divided among several agencies.

Current Department of Defense contingency planning anticipates direct usage of the waterways system principally at ports where military unit equipment and

resupply cargo will be transferred to ships. Although not suited for the rapid deployment of military units, the waterways system may provide a capability to move resupply cargoes and certain strategic stockpile materials in an efficient manner. Future planning should address the capability of the waterways system to move such cargoes and reduce the transport demands on the rail system.

In reviewing the past role of the waterways system during military conflicts, there were three significant factors identified which are unlikely to be present in future contingencies:

1. They all took place on foreign soil, with no disruption of United States industry or transportation systems resulting from hostile attack.

2. The United States was relatively self-sufficient in terms of raw materials and energy supplies, and sea control was either not challenged or was achieved relatively quickly.

3. A long and reasonably orderly mobilization of the armed forces and industrial base occurred.

Current military contingency plans show that past experience will not be repeated. Such factors as rapid mobilization, high intensity short duration conflicts and insecure sea lanes suggest that reformulation of the national defense role of the waterways system is necessary, and that existing resource allocation mechanisms may be inappropriate for such an environment.

NONDEFENSE EMERGENCY ROLE OF THE WATERWAYS SYSTEM

Federal emergency planning encompasses a variety of crisis situations which can affect the waterways system. Plans have been developed to cover natural disasters, labor disruptions, other types of disasters (such as explosions or fires), and national emergencies. Each of the federal agencies assigned responsibilities for emergency planning are required to develop, implement, test, and update those plans.

The common philosophy of all nonmilitary emergency planning is to develop an organizational structure capable of responding quickly and flexibly to whatever situation may develop. The United States Army Corps of Engineers and United States Coast Guard have incorporated such planning as part of their normal district functions. The principal requirement is to ensure that those plans are up-to-date and that they anticipate likely emergency situations. Likewise, those agencies should make sure that adequate materials and other resources are available to implement emergency plans.

The principal role for the waterways system during any emergency is likely to be the movement of fuels, bulk materials used in the production of critical materials, and water purification materials, as directed by emergency control authorities.

WATERWAYS SAFETY, INCLUDING HAZARDOUS MATERIALS ISSUES

In FY 78, over 4,000 vessel casualties involving more than 7,000 vessels were reported to the United States Coast Guard. A vessel casualty is reported whenever there is: actual physical damage to property in excess of $1,500; material damage affecting the seaworthiness or efficiency of a vessel; a stranding or grounding (with or without damage); loss of life or injury.

About 3% of FY 78 vessel casualties occurred in waters outside the jurisdiction of the United States. Estimated damages to vessels, cargo and other property approached $200 million. Over the last decade, personnel deaths and injuries due directly to a vessel casualty have averaged about 200 deaths and 150 injuries annually. During the same period, approximately 350 deaths and 1,300 injuries occurred annually when no vessel casualty was involved. Such deaths and injuries typically stem from slips, falls, bad weather, the operation of machinery, or natural causes.

Four types of vessel casualties are of major concern to the NWS since their causes can be influenced by waterways systems strategies. These are collisions, rammings

(collisions with a fixed object or moored vessel), groundings, and cargo fires and/or explosions. The first three types are characterized as vessel control accidents, and as a group they represent about 60% of all vessel casualties, and account for about 50% of all estimated damages.

Vessel control accidents have been found to be caused primarily by human error, either through the incorrect assessment of navigation conditions, or by the failure to perform those tasks which would have prevented the accident. Furthermore, vessel control accidents have been found to occur most frequently in those segments of the waterways system with one or more of the following characteristics:

- Bends.
- Channel intersections.
- Locks.
- Narrow channels.
- High vessel traffic levels.

An analysis by the NWS study team of United States Coast Guard casualty records for United States waters covering Fiscal Years 1977 and 1978 indicated that slightly more than half of the vessel control accidents occurred in coastal or port areas. On the shallow-draft Gulf Coast and Mississippi River Systems, over 85% of the vessel control accidents occurred on the following five waterways segments. These five segments accounted for about 75% of the total 1977 ton-miles on the shallow-draft Mississippi/Gulf System.

- Gulf Intracoastal Waterway - West.
- Lower Mississippi River.
- Upper Mississippi River.
- Illinois Waterway.
- Ohio River.

- Lower Mississippi River.
- Upper Mississippi River.
- Illinois Waterway.
- Ohio River.

The risks associated with waterways system accidents are greatest when hazardous materials are being carried, since they present fire, explosion, toxic vapors, and environmental damage hazards. The level of risk associated with waterways accidents rises significantly when bridges, terminals facilities, locks and dams, and populated areas are in the vicinity of an accident involving hazardous materials. These risk-increasing factors tend to be simultaneously present and concentrated at a relatively few locations.

Existing regulations governing the transport of hazardous materials by water were developed principally during the 1970s, although United States Coast Guard vessel design, construction, inspection and maintenance regulations are long-standing. Recent legislation requiring these regulations included the Ports and Waterways Safety Act of 1972, amended in the Port and Tanker Safety Act of 1978; the Hazardous Materials Transportation Act of 1974; and the Federal Water Pollution Control Act of 1972, amended in the Clean Water Act of 1977. Regulations governing hazardous materials movements on the waterways have been issued by the United States Coast Guard, the Materials Transportation Bureau, the Environmental Protection Agency, and about one-half of all states in coastal regions. United States Department of Transportation regulations govern the labeling, packaging, marking and preparation of shipping papers for hazardous materials shipments by all transport modes.

Whereas the hazardous materials regulations tend to emphasize safe handling and transport methods and the prevention of spills into the marine environment, there is another regulatory area which relates to overall marine operations safety. This latter area represents the main direction of United States Coast Guard regulations and

safety programs. Significant recent developments in this area include Vessel Traffic Systems, new standards for vessel steering and communications equipment, improved personnel training and licensing programs, and adoption of international marine safety conventions.

An unfortunate result of this regulatory process has been confusion and difficulty in compliance on the part of both shippers and carriers, as well as a significant increase in the cost of hazardous materials transport. The compliance program has been further compromised by underfunding and understaffing of inspection teams, as well as by a lack of uniformity in the enforcement and interpretation of rules. Another result of these programs has been that some carriers have decided to stop handling certain types of hazardous materials - most notably, benzene because the costs of compliance were judged to be too high.

For the formulation of national waterways strategies, this research has concluded that there are three areas related to marine safety which should be addressed.

1. The impact of hazardous materials regulations and the projected waterborne traffic demands associated with such commodities.

2. Marine safety and pollution control programs administered by the United States Coast Guard.

3. Safety-related waterways structural improvement and modification projects of the United States Army Corps of Engineers.

Another conclusion of this element is that a few sections of the waterways system which can be readily identified account for the majority of vessel control accidents. Many of these waterways also carry significant volumes of hazardous commodities, and prevention of hazardous materials accidents is a primary waterways safety issue. Therefore, any NWS strategy for reducing accidents can focus primarily on correcting the safety problems in specific waterways locations.

Such actions as enhanced crew training and licensing procedures, improved vessel steering, communications and navigation systems, improved tow lashing equipment, and better navigation aids programs can be addressed as both policy and budgetary issues. Consolidation of navigation rules and simplification of regulations are primarily policy issues.

Specific actions which can be directly evaluated within the context of NWS strategies are:

1. Channel improvement and maintenance programs for elected locations, to improve navigation clearances and reduce navigation hazards.

2. Alteration, replacement or removal of bridges which represent a hazard to navigation.

3. Installation of effective protection and guidance structures and/or improved navigation aids at bridges, locks, dams and piers.

4. Implementation of Vessel Traffic Services at selected locations, varying the design to meet specific situational conditions.

5. Installation of fire protection systems at selected locks which handle a high volume of flammable commodities.

Criteria for choosing locations where these actions would most likely prove beneficial will be developed in Element K2/L, along with representative costs of implementation.

The impact associated with hazardous materials regulations can be evaluated through waterborne traffic flow forecasts. The effect of such regulations is primarily economic, and they can change the relative cost competitiveness of the water mode with respect to both rail and pipeline. In certain stringent environmental policy scenarios, an outright ban on the movement of certain materials by water is possible.

I - HISTORICAL AND CURRENT NATIONAL DEFENSE USAGE OF THE WATERWAYS SYSTEM

INTRODUCTION

Although the term "national defense" is in common usage, the connotation varies depending on the context. The Defense Production Act of 1950, as amended, defines national defense as: (1) military and atomic energy production or construction; (2) military assistance to any foreign nation; (3) stockpiling; (4) space development; and (5) other directly related activities.[1] This interpretation focuses on the industrial production base for military items.

Other aspects of national defense are also relevant to the entire United States transportation system. One of these is the transport of supplies and equipment used by military units stationed both domestically and overseas. Another important role is the deployment of military equipment and supplies to a theatre of operations during hostilities. The transport system must support the general economy at such times, and may be called upon to move supplies which will aid the economies of allied nations. Finally, the waterways system has the unique role of providing access to facilities which support the United States Navy fleet.

This section of the Element E/F report examines the usage of the waterways system in support of the national defense both historically and at present. All of the functions mentioned will be reviewed as they have been employed to date, noting the different roles of the inland and deep-draft segments of the system.

HISTORICAL USAGE

(a) The Period through World War I

During the Civil War, military strategy was based upon control of the Ohio, the Mississippi, the Tennessee and

other rivers, which at that time were the only transportation routes capable of carrying large amounts of material. Railroad development after the war was very rapid, going from about 35,000 miles of line in 1865 to 230,000 miles by 1907. This rapid expansion, coupled with unbridled rate competition, nearly eliminated inland river and canal navigation. During the period from the Civil War to World War I, navigation improvements were primarily directed toward coastal ports.

The modern history of United States inland waterways transportation system began with the appointment of an Inland Waterways Commission by President Theodore Roosevelt in 1907. In his message to the Senate and House of Representatives transmitting the Preliminary Report of the Inland Waterways Commission in 1908, President Roosevelt stated:

> "Our river systems are better adapted to the needs of the people than those of any other country. In extent, distribution, navigability, and ease of use, they stand first. Yet the rivers of no other civilized country are so poorly developed, so little used, or play so small a part in industrial life of the nation as those of the United States. In view of the use made of rivers elsewhere, the failure to use our own is astonishing, and no thoughtful man can believe that it will last."
>
> "The development of our inland waterways will have results far beyond the immediate gain to commerce. Deep channels along the Atlantic and Gulf coasts and from the Gulf to the Great Lakes will have high value for the national defense."

Wnen hostilities broke out in Europe in 1914, the withdrawal of foreign ships from the United States trades was compounded by a small American fleet. To alleviate the shipping shortage, Congress enacted emergency legislation in 1914 which permitted foreign flag ships to be transferred to United States registry. After two years of debate, Congress passed the Shipping Act of 1916 which established a Shipping Board of five commissioners and provided for the construction and acquisition of ships for

commercial operation. Over 2,300 oceangoing merchant ships were produced under the purview of the United States Shipping Board Emergency Fleet Corporation (authorized on June 15, 1917), although few ships were available for use during the period when the United States was at war.[2]

When the United States entered World War I in 1917, there were practically no river transportation facilities, and dependable river channels adequate for large scale use were not available. Unprecedented demand for transportation brought about by the war, coupled with poor logistics management, congested the railroads and ports to such an alarming extent that it became necessary to relieve the situation.

In June of 1917, the Council of National Defense called upon several experts in the field of water transportation to form a Committee on Inland Water Transportation, with the Chief of Engineers of the United States Army named as chairman. The particular purpose of the committee was to study the feasibility of utilizing the navigable waterways of the United States to relieve the wartime freight congestion on the railroads.

In 1917, the United States Shipping Board, upon the recommendation of the President, allotted $3,960,000 from the funds of the Emergency Fleet Corporation for building barges and towboats to be used on the Mississippi River from St. Louis to St. Paul. Under the direction of the Committee on Inland Water Transportation, some use was made of barges and towboats on the Mississippi River in 1917. This constituted the first direct government operation of water transportation facilities.

War exigencies, however, demanded a unified approach to the transportation difficulties, and accordingly there was created a United States Railroad Administration which assumed the duties of the Committee on Inland Water Transportation with respect to the construction and operation of the barge lines. The director general of the Railroad Administration was vested with broad powers for the creation and coordination of transportation agencies during the emergency. On February 15, 1918, the Committee

on Inland Water Transportation was dissolved and its records turned over to the Railroad Administration. The director general of the latter agency thereupon appointed a Committee on Inland Waterways to look into ways and means of putting barge transportation to use for the war effort.

Based on the recommendations submitted to the director general by the new Committee on Inland Waterways, the director general commandeered all privately owned floating equipment on the New York State Barge Canal and on the Mississippi and Warrior Rivers, and initiated the construction of new floating equipment to cost $12,000,000 for more extensive operations on these three water routes.[3]

(b) Between World War I and World War II

The Railroad Administration continued to operate boats and barges until March 1, 1920, when, under the provisions of the Transportation Act of 1920, its equipment and their operation were turned over to the Secretary of War. However, the Railroad Administration's impact upon the development of our inland waterway transportation system as described by Professor Marshall E. Dimock is noteworthy:

> "In the closing days of the Railroad Administration an effort was made by the railroad men in charge of this waterway service to establish certain definite territory for interchange with the railroads, and certain guiding principles for division of rates. It is impossible to conceive of any principles being laid down for such divisions more calculated to destroy water transportation than those laid down by the Railroad Administration."[4]

The Transportation Act of 1920 reflected the prevailing sentiment that the experiment in waterway transportation should be undertaken by the federal

government. As a result, the barge service (except for the New York Barge Canal) under the direction of the Secretary of War became known as the Inland and Coastwise Waterways Service. Due to rigid regulations imposed by the federal government, the effectiveness of this Service was severely hampered.

As a result, the Inland Waterways Corporation (IWC) was created in 1924 to prove the economical character of inland waterways transportation, and to engage in a pioneering and development barge service program on routes which were expected to show initial losses. By the beginning of World War II IWC's service had been extended, and operations were being conducted over the full length of the Mississippi River from New Orleans to Minneapolis, from St. Louis to Chicago on the Illinois River, and from St. Louis to Kansas City on the Missouri River. The equipment then consisted of 28 power vessels aggregating 37,660 horsepower, and 277 cargo barges with an aggregate capacity of 448,700 net tons.[3]

The disposal of surplus government-owned ships after World War I presented problems to the United States Shipping Board. After lengthy debate, Congress attempted to facilitate disposal of the ships through the Merchant Marine Act of 1920. The act is also notable for three major policies it enunciated:

1. Its "Declaration of Policy" which for the first time stated unequivocably:

> "That it is necessary for the national defense and for proper growth of the foreign and domestic commerce that the United States shall have a merchant marine of the best equipped and most suitable types of vessels sufficient to carry the greater portion of its commerce and serve as a naval or military auxiliary in time of war or national emergency, ultimately to be owned and operated privately by citizens of the United States..."

2. Section 27, which reserves operations in the United States coastwise, intercoastal and noncontiguous trades to United States-built ships manned by United States citizen crews.

3. Section 19, which offered a means of protecting United States flag shipping against foreign discrimination.

Disposal of surplus ships remained slow, causing large segments of American merchant marine to remain under the direction of the United States Shipping Board. To encourage the development of a privately-owned merchant marine, Congress passed the Merchant Marine Act of 1928, which reaffirmed the Declaration of Policy of the 1920 Act. Progress remained less than satisfactory, and a series of investigations and studies on the merchant marine by the Executive Branch and hearings before Congressional Committees were conducted between 1930 and early 1936. Acting on the preferences of President Roosevelt, Congress passed the Merchant Marine Act of 1936.[2]

The 1936 Act (as amended) includes the following Declaration of Policy:

> "It is necessary for the national defense and development of its foreign and domestic commerce that the United States shall have a merchant marine, (a) sufficient to carry its domestic water-borne commerce and a substantial portion of the water-borne export and import foreign commerce of the United States and to provide shipping service essential for maintaining the flow of such domestic and foreign water-borne commerce at all times, (b) capable of serving as a naval and military auxiliary in time of war or national emergency, (c) owned and operated under the United States flag by citizens of the United States insofar as may be practicable, (d) composed of the best-equipped, safest, and most suitable types of vessels, constructed in the United States and manned with a trained and efficient citizen personnel, and (e) supplemented by efficient facilities for shipbuilding and ship repair."

An independent Maritime Commission was created to replace the United States Shipping Board. Two basic

subsidy programs were established. The first, designed to sustain the shipbuilding and repair industry, equalizes the cost to United States ship operators of acquiring vessels from United States yards with respect to foreign yards. Vessel designs must meet government criteria, primarily based upon features useful in national emergencies. The second, called operating differential subsidy, compensates for the differences between United States vessel operating costs and those of foreign vessels. These reforms proved timely, with World War II soon to begin.

(c) World War II

At the outbreak of World War II, the entire domestic transportation system, including the inland waterways, was placed under control of the Office of Defense Transportation. The barge and towing industry operated under the Inland Waterways Division of the Waterway Transport Department of the Office of Defense Transportation. Coastwise, intercoastal transport, and the Great Lakes were each handled by separate divisions.[5] Due to the great demand for ships on the North Atlantic routes, nearly all deep-draft intercoastal and coastwise shipping services were suspended. Much of this traffic was shifted to both shallow-draft vessels and railroads.

The IWC, in November, 1942, entered into an agreement with the Defense Plant Corporation, which was directing a crash program to build needed equipment during World War II. Under this agreement, IWC agreed to serve as a chartering agency for privately owned barges as well as its own barges. The IWC agreed to assist in a conversion and construction program designed to provide additional towboats and barges, primarily for the transportation of petroleum products.[3]

At the time the inland waterways fleet was mobilized, it included 1,000 towboats and 5,000 barges operating over the Gulf Intracoastal Waterway from St. Marks, Florida, to Corpus Christi, Texas; the Mississippi-Illinois-Ohio-Missouri River System; the Atlantic Intracoastal Waterway from Jacksonville, Florida to Norfolk, Virginia; the New York State Barge Canal; smaller river tributaries of these main-stem waterway systems; and some Pacific Coast rivers.[5]

1. Inland Waterway Cargo Movements. The major achievements of inland waterways transportation during World War II included movement of large quantities of strategic commodities, goods, and supplies which were required for total war production, thereby easing the burden placed on other forms of transportation. Many industries vital to the war effort could not have operated effectively without the availability of inland water transportation.

> "Certain waterways contributed more than others to the war effort. In general, the long-haul waterways showed the greatest wartime traffic gains. During the war period, the total annual ton-mileage more than doubled the record peacetime movement on the Mississippi, Ohio, and Illinois Rivers, waterways that connect such large metropolitan centers as New Orleans, St. Louis, Minneapolis, Chicago, Pittsburgh, and others. The Gulf Intracoastal Waterway, southern supporting link of the inland waterway system, was extremely valuable in the transportation of strategic commodities, particularly of crude and refined petroleum, and in 1944 carried five times as much freight as in 1939."[6]

> "Military production planners relied heavily upon barges for many complete movements, but perhaps one of the outstanding roles of the barges was that which they performed in combination with other modes of transportation. The water movements made by the barge lines in conjunction with pipelines, tank cars and tank trucks brought about the most efficient coordination of transportation facilities the country has ever seen."[5]

Barges were credited with transporting a total of 1,732,030,485 barrels of petroleum and petroleum products during the war years, the equivalent of more than seven million tank car loads, representing 72,732 trains of 100 cars each.

The situation with respect to petroleum movements was extremely critical in the early war years before an effective antisubmarine campaign could be mounted. German submarines were able to sink tankers moving along the Atlantic Coast almost routinely. During this period, the inland and intracoastal waterways were called upon to deliver some 1.3 million barrels of petroleum products daily. The Atlantic Intracoastal Waterway carried more than a billion ton-miles of traffic in 1942 and 1943, the peak years of submarine warfare, a level twice that of the prewar years.[6] Twenty-one steam-powered, screw-propelled towboats were commissioned by the Defense Plant Corporation for petroleum service, with the first entering service in mid-October, 1943.[7] Development of effective antisubmarine techniques, including the use of blimps, and completion of the "Big Inch" and "Little Inch" pipelines by the government, relieved much of the pressure on the waterways system.

However, use of the inland waterways remained relatively small throughout the war, primarily for three reasons: water delivery was slow in comparison to rail; Army transportation officers were unfamiliar with the service; and equipment was in short supply because of the diversion of steel to other uses. Peak wartime Army usage reached 200,000 tons per month, but the total water traffic for the period December, 1941, to December, 1945, was 4,110,000 tons, only 1.2% of total Army traffic. Rail, on the other hand, carried 90.6% of the Army's domestic freight. During 1943 and 1944, bulk petroleum products constituted about 82% of total Army inland water freight, with the remainder made up of general supplies and motor vehicles. In 1945, the Army shipped grain down the Mississippi River as part of the European civilian relief program.[8]

2. Inland Shipbuilding.

> "Another remarkable wartime achievement of the inland waterways industry was in the shipbuilding and repair field. Under the impetus of World War II the number of inland shipbuilding and repair facilities increased from 85 to 140. Shipyards were built on practically all inland waterways where the construction of many different types of oceangoing vessels contributed much to the successful termination of the war."

"This could be done only because it was possible to move these vessels from construction yards at inland points to the ocean via the inland waterways. Inland shipyards turned out more than 4,000 vessels including submarines, torpedo boat tenders, coastal transports, auxiliary repair ships, aircraft rescue vessels, destroyer escorts, barges, oceangoing cargo ships, floating cranes, Coast Guard cutters, patrol craft, subchasers, tugboats, tank ships and all types of military landing craft."

"Tankers designed to deliver aviation gasoline to Navy fighting planes in all parts of the world were built in the wheat fields of Minnesota. Twenty-eight of the Navy's largest submarines were built on Lake Michigan, at Manitowoc, Wisconsin, and taken under their own power to Chicago. There they were loaded into huge floating docks, especially designed for that purpose, for the long trip down the Illinois and Mississippi rivers to the Gulf of Mexico where they were commissioned with Navy crews and sent off to join the fighting forces in the Pacific and elsewhere in the world."

"Some 43,744 tons of structural ship sections were built at inland shipyards along or adjacent to the Ohio River. War vessels constructed at inland points were successfully, safely, and efficiently moved to deep water over the inland waterways system. Many of them, because of their drafts, had to be pontooned or otherwise floated and towed to sea."[5]

3. Cargo through Ports. Deep-draft ports were heavily utilized throughout World War II. The Army assumed control of certain commercial facilities and also operated its own terminals. Table I-1 details the large volumes of cargo handled at the ports. Not shown is the cargo handled by the United States Navy through its own facilities. All of the ports listed in Table I-1 had separate military-owned terminals within the port area, with traffic also moving through nearby commercial terminals. In order to control the movement of cargo through ports, a series of Holding and Reconsignment Points were established at inland locations convenient to

major rail lines which served the principal ports. Cargo could move into the ports only upon specific direction from transportation officers.

Special terminals were established by the military to handle ammunition and explosives. These terminals were constructed in relatively undeveloped areas to limit potential damage in case of explosions. A total of 11,467,346 short tons of such commodities moved through seven North Atlantic, one South Atlantic, three Gulf, and five Pacific Coast ammunition ports.[8]

In 1939, the United States merchant marine active fleet was 739 vessels totalling 5,394,000 deadweight tons.[9] Between 1939 and 1946, about 5,600 ships totalling more than 56 million deadweight tons were constructed in United States shipyards. [2]

Table I-1

Tons of Cargo Shipped to Overseas Destinations by the Principal Army Ports: December 1941-December 1945 (1)

Shipping Ports	Total	1941 (December Only)	1942	1943	1944	1945
All Ports	132,119,553	284,023	11,834,995	28,500,226	45,512,945	42,987,344
Boston	9,481,780	160	600,612	1,959,969	3,953,680	2,967,359
New York	38,524,545	75,257	3,717,884	10,116,328	15,861,674	8,753,402
Philadelphia	5,592,170	346	4,541	743,729	2,772,146	2,431,408
Baltimore	6,865,643	0	51,290	1,028,166	2,811,494	2,974,693
Hampton Roads	12,955,734	7,277	337,900	3,020,069	5,464,725	4,125,763
Charleston	3,675,088	5,543	386,242	672,139	1,092,313	1,518,851
New Orleans	9,164,364	2,423	485,346	1,495,561	3,293,091	3,887,943
San Francisco	25,028,759	101,645	3,486,401	5,555,283	7,711,629	8,173,801
Seattle	12,516,683	50,314	1,791,916	3,025,496	3,550,057	4,098,900

Note: (1) The ports shown are the eight at which the Army operated ports of embarkation and the two (Philadelphia and Baltimore) at which the Army operated cargo ports. While the greater part of the cargo was loaded directly at these ports, some was loaded also at officially designated subports and at other ports located near and supervised by the principal ports. Of the unnamed ports, the larger tonnages were loaded at Searsport, ME (470,000 M.T.), a subport of Boston; Prince Rupert, BC (950,000 M.T.), a subport of Seattle; and Portland, OR (1,800,000 M.T.), a subport of San Francisco through August 1944 and a subport of Seattle thereafter.

Source. United States Army in World War II, The Technical Services, The Transportation Corps: Movements, Training and Supply.[8]

(d) Post World War II

After the cessation of hostilities in 1945, there was a transition period in which large volumes of equipment and supplies were returned to the United States. Rapid demobilization of the armed forces occurred, and with it came the deactivation of most military-owned vessels and terminals. The assets of the Inland Waterways Corporation were sold to St. Louis Shipbuilding, with the carrier still doing business as Federal Barge Lines.

The government's excess inland river fleet was laid up near Madisonville, Louisana, on the East Pearl River. The Merchant Ship Sales Act of 1946 provided for disposal of ships and established the National Defense Reserve Fleet (NDRF). Several anchorage areas were established for the large numbers of merchant and naval auxiliary ships that had been constructed during the war. Most of the vessels were eventually sold to commercial interests, transferred to other government service, or scrapped. A fleet of inactive ships has been maintained throughout the postwar era. Some of the ocean terminals remain in military use, but many were declared excess and have been transferred to local port authorities or other governmental bodies.

During the Korean War, ships from the National Defense Reserve Fleet were activated and used to supplement both the commercial fleet and the United States Navy. Ocean carriers were called upon to man and operate most of the NDRF cargo ships under general agency agreements and contracts. Most military cargo moved into Japan, which acted as the primary logistics base for the United Nations forces. At the cessation of hostilities, the NDRF ships were once again deactivated.

(e) The Vietnam Conflict

United States military support to South Vietnam was primarily advisory until January, 1965, when the Third Marine Division established a base at DaNang. United States forces in Vietnam increased until 1968, and remained at peak levels until 1971. Withdrawals of United

States forces occurred from 1971 through 1973, but substantial military aid shipments continued until early 1975. All of the cargo shipped to Vietnam was handled under the direction of the Military Sea Transportation Service (now Military Sealift Command). From 1958 to 1966, the total annual traffic moved by MSTS fluctuated between 10.8 and 13.5 million measurement tons of dry cargo, but by 1968 it had grown to 28.7 million tons.[9] During this conflict, NDRF ships were once again activated.

Data from Waterborne Commerce Statistics were reviewed for the years 1969 through 1977 for six commodities: (1) Department of Defense cargo - special items; (2) aircraft and parts; (3) ordnance and accessories; (4) gasoline; (5) jet fuel and kerosene; and (6) distillate fuel oil (diesel fuel). These commodities, considered important to the military effort, were summarized for waterborne exports and domestic flows. Exports, shown in Table I-2, include some events that need clarification. DOD cargo and aircraft parts reflect military assistance shipments and replacement equipment for United States forces overseas, as well as Vietnam shipments; exports have thus remained fairly stable. During 1974 and 1975, material was being sent to both Vietnam and Israel in large amounts, the former because United States forces had withdrawn: and the latter to replace losses from the Yom Kippur War in late 1973.

Total waterborne flows in 1969 through 1977 for these commodities are reported in Appendix B. No domestic shipments were recorded for DOD controlled cargo in this period. Aircraft and parts shipments were sporadic during the period; the most significant movements occurred within the Pacific Coast area and between that area and Alaska-Hawaii, until 1975, when they dropped off significantly. Domestic ordnance shipments declined continually in the period, with most shipments moving to/from Alaska, Hawaii, or Puerto Rico. Total domestic flows for both categories have typically been below 5,000 tons annually, an almost insignificant amount.

During the Vietnamese War, fuel movements to Southeast Asia and Guam were quite large, especially jet fuel.

However, the Waterborne Commerce Statistics show almost no significant exports of jet fuel, gasoline or distillate fuel oil (diesel fuel) from the United States (see Table III-4) during the period 1969 through 1975. Interviews with the Military Sealift Command indicated that nearly all of the fuel consumed by the United States military forces in Southeast Asia was procured either in the Middle East or the Caribbean. Thus, impacts on the United States waterways system due to fuel consumption in Vietnam were insignificant.

The only noticeable upturn in petroleum product exports reported in the Waterborne Commerce Statistics occurred in 1973. All light oil product exports increased greatly in a period which corresponded to the Yom Kippur War. Given the low volume of exports in other years, it appears that a few shipments of petroleum products to Israel late in 1973 caused the increase in exports.

(f) The Space Program

A unique role played by the waterways has been the movement of missile and rocket components for the National Aeronautics and Space Administration (NASA). Movements of booster sections by water were common during the Saturn V program. NASA facilities which used the waterways system were the Michoud Assembly Facility on the Gulf Intracoastal Waterway, 15 miles east of New Orleans; the Mississippi Test Facility (now the National Space Technology Lab) on the East Pearl River near Bay St. Louis, Mississippi, and the Kennedy Space Center at Cape Canaveral, Florida. At the request of NASA, the Canaveral Harbor lock design was increased to 90 feet by 600 feet, with NASA bearing the additional cost of $700,000.

Now that the Space Shuttle will become the primary space vehicle, water movements will decline because transfer of the shuttle vehicle will be primarily by modified Boeing 747 aircraft. Segments of the solid rocket booster will be moved via rail. However, assembled external tank units will move via ocean barge from Michoud to Cape Canaveral and Vandenberg Air Force Base, California, at about 40 units total per year.

Table I-2

Total Exports of Military Supplies
(Thousands of Tons)

	1969	1970	1971	1972	1973	1974	1975	1976	1977
DOD Cargo - Special Items	281.9	318.4 (12.9)	289.7 (-9.0)	253.4 (-12.5)	222.7 (-12.1)	210.5 (-5.5)	271.3 (28.9)	222.3 (-18.1)	239.9 (7.9)
Aircraft and Parts	10.4	12.0 (15.3)	12.0 (0.1)	12.9 (7.5)	12.0 (-7.0)	16.3 (35.8)	18.4 (12.9)	16.4 (-10.9)	15.1 (-7.9)
Ordnance and Accessories	3.4	3.6 (5.9)	3.0 (-16.7)	4.8 (60.0)	4.1 (-14.6)	6.9 (68.3)	8.6 (24.6)	5.3 (-38.4)	4.7 (-11.3)
Gasoline	208.4	114.4 (-45.1)	210.9 (83.9)	70.4 (-66.6)	338.6 (381.1)	74.3 (-77.7)	16.0 (-78.8)	22.6 (41.4)	90.9 (302.9)
Jet Fuel and Kerosene	48.4	20.5 (-57.7)	24.1 (17.6)	32.6 (35.4)	101.8 (212.4)	78.1 (-23.3)	39.8 (-49.1)	17.5 (-56.0)	7.8 (-55.5)
Distillate Fuel Oil	825.0	300.9 (-63.5)	230.7 (-23.3)	120.2 (-47.9	604.7 (-403.2)	102.9 -83.0	101.7 -1.1	22.5 -77.9	12.3 -45.3

NOTE: Year-to-year percentage change is shown in parentheses.

SOURCE: Waterborne Commerce Statistics.

PROJECT JUSTIFICATIONS BASED ON NATIONAL DEFENSE

The national defense role of the waterways system has been cited in the past as justification for new waterways projects. Primary emphasis has been upon movement of materials vital to the production of military supplies and equipment. Selected references discovered in research for the National Waterways Study are noted below.

1. Wilson Dam at Muscle Shoals, Alabama. The National Defense Production Act of 1916 authorized the President "...to determine the best means for production of nitrates and other products for munitions of war; to designate for use by the United States such sites on rivers or public lands as he deems necessary to carry out the purpose of the Act; to construct, maintain, and operate on any such site, navigation improvements and power houses as he deems best for generation of power for production of nitrates or other products for munitions of war and useful in the manufacture of fertilizers and other useful products."

Although there was no intention to use the dam power for production of war materials in time of peace, the Supreme Court concluded that the assurance of an abundant supply of electric power in the event of war constitutes a national defense asset.[6] Wilson Dam (Dam No. 2) and its two locks were opened to navigation in 1927. Widows Bar Dam opened in 1925 and Dam No. 1 in 1926, both of which have since been replaced. The plant for the production of nitrates is the currently inactive Phosphate Development Works at Sheffield, Alabama. The entire project was integrated into the TVA in 1933.

2. United States Navy Projects. At various times, certain harbor projects have been authorized primarily to accommodate United States Navy requirements. Examples include Norfolk Harbor, Virginia, in 1907, 1910, and 1917; Charleston Harbor, South Carolina, in 1918 and 1940; and San Diego, Los Angeles and Long Beach harbors, California, in 1940. Such projects coincided with the development of new facilities, or the introduction of deeper draft vessels.

3. Gulf Intracoastal Waterway. The Rivers and Harbors Act of July 23, 1942, authorized an increase in project dimensions from 9 feet by 100 feet to 12 feet by 125 feet, in the section from Apalachee Bay, Florida, to Corpus Christi, Texas, except between New Orleans, Louisana, and Mobile Bay, Alabama, where the width authorized was 150 feet. Motivation for the improvement was the need to move vast quantities of petroleum products along this route, due to wartime demands and the lack of adequate capacity on other modes. Included in the project was the construction of a petroleum products pipeline from Port St. Joe, Florida to Jacksonville, Florida.

4. MacArthur Lock, St. Mary's River, Michigan. Heavy iron ore traffic through the Soo Locks during World War II strained the capacity of the existing facilities. Between 1942 and 1943, the old Weitzel Lock, which had been built by the State of Michigan in the 1800s, was destroyed and replaced by the MacArthur Lock. Additionally, the North Channel was deepened to 27 feet.

Projects which were considered by Congress sometimes involved potential national defense aspects. Some of the issues raised with regard to specific projects are noted below.

1. Gulf and Atlantic Intracoastal Waterways. The 1955 Marine News Company publication "Know Your Waterways" noted the national defense aspects of completing these projects as follows:

> "If the Cross-Florida Canal were completed, the New Jersey Intracoastal Waterway extended to New York Harbor, some widening and deepening done along the Atlantic Coast channels, and the Gulf Intracoastal Waterway extended from St. Marks, Florida, to the Gulf entrance of the authorized Cross-Florida Canal, there would be a safe, unbroken intercoastal waterway from the Mexican border to Boston, Massachusetts. Oil and other materials from the Gulf Coast could then be transported safely and at low cost to points on the Atlantic Seaboard, while products of the East Coast industries could reach Gulf ports at low costs. Such a waterway might easily become

indispensable; in event of emergency it could become a vital link in the nation's defense and transportation system."

2. Tennessee-Tombigbee Waterway. One Congressman's logic supporting this project was that it provided a "missing link" in our national defense system.[10]

3. Florida Cross-State Canal. One argument advanced to justify this project was that in time of war "...the canal could save the government the expense of maintaining a fleet to protect American commerce in the Florida Straits and also facilitate the safe and speedy movement of war troops and naval vessels between the Gulf and the Atlantic."[11]

4. Yazoo River Project. In 1940, a Congressman submitted correspondence recommending funding of this project due to the Tinsley oil field development in Yazoo County, Mississippi, and the resulting impact such a fuel source could have on the national defense posture.[10]

5. Ouachita River Project. During World War II a plan for dredging and expansion of this waterway was under consideration. A rationale for the project advanced by a Congressman was that it would facilitate the transportation of bauxite to aluminum plants supplying material for the war effort.[10]

In summary, there were very few waterways projects which were authorized with national defense use as a primary justification. On the other hand, the Congress has for a long time recognized that an adequate, extensive waterways system contributes to a strong industrial base and provides the flexibility to relieve other modes whenever they become overburdened. The performance of the inland waterways during World War II clearly reflects their important role during wartime conditions.

CURRENT DEFENSE REQUIREMENTS

During peacetime, there are two ongoing defense requirements for the waterways system. The first is to

transport military supplies for the Department of Defense, domestically and internationally. The other is to maintain access to deep-draft facilities which support naval operations.

(a) Military Traffic

The Department of Defense (DOD) is the largest single customer for transportation services in the United States, shipping a wide variety of goods. It has been the policy of DOD to rely upon commercial transport companies for both peacetime and contingency requirements. DOD-owned transportation assets consist of equipment which satisfies movement requirements when commercial transport is unavailable or insufficient, or when special capabilities are required.

Surface transportation for DOD is managed by the Military Traffic Management Command (MTMC), which is also the manager of military-owned common-user ocean terminals. Ocean transport is provided by the Military Sealift Command, with cargo bookings handled through MTMC. Normal traffic routing authority has been delegated to certain large military organizations, including the Defense Logistics Agency.

MTMC handled 15,391,631 tons of domestic cargo in FY 78, based on Government Bill of Lading records, at a cost of $426.6 million. The tonnage shares by mode were 30.1% for truck, 15.6% for rail, 33.2% for pipeline, 19.6% for water, 1.2% for air, and 0.3% for bus and freight forwarders.[12] These figures exclude indirect transportation connected with procurement contracts and shipments moving on commercial bills of lading.

An MTMC study of inland waterways for national defense[13] examined cargo movements for FY 76 using Government Bill of Lading records. A review of the MTMC study's data in light of information received from the Defense Fuel Supply Center for NWS indicates that petroleum products accounted for 98% of all FY 76 waterways movements. The data also shows several

shipments of aircraft parts and other machinery between naval installations, although the tonnage was small. The overall pattern of waterway movements was along coasts and within coastal harbors and bays. Shallow-draft inland river movements, excluding points on the Mississipi River below Baton Rouge, totaled only 6,336 tons of the 684,371-ton total. An MTMC review of FY 77 Government Bill of Lading records indicated similar waterways traffic as in the prior year.

Information was received for the National Waterways Study from the Defense Fuel Supply Center (DFSC), a component of the Defense Logistics Agency, regarding petroleum products movements in FY 78. DFSC is the sole source for all DOD fuel procurements worldwide. In FY 78, about 179 million barrels of petroleum products were moved by DFSC. Nearly all movements are of "clean products," with jet fuels predominating. Tanker movements comprised 47% of the total FY 78 volume, with such movements in the United States currently at 2.0 to 2.5 million barrels per month. Other mode shares in FY 78 were 23% by pipeline, 13% by barge, 10% by truck, and 7% by rail (based on barrels moved).

Using the DFSC-supplied conversion factor of 303 gallons per short ton, the pipeline and barge fuel moves were 5.7 and 3.2 million tons, respectively. This indicates that fuel accounts for essentially all military shipments by MTMC via those modes. The Department of Defense accounts for only about 3% of total United States fuel consumption, but Bureau of Mines data for 1976 show that the military accounts for 14.6% of aviation gas and 25.5% of jet fuel demands.

Appendix A is an unaudited listing of FY 78 DFSC fuel movements by barge, indicating receiving and shipping activities and their location by NWS Segment. Shipping activities are either the refineries of suppliers, commercial terminals associated with pipelines, or DFSC-operated distribution terminals which receive products via tanker. Table I-3 summarizes the information contained in Appendix A by NWS Region; the difference in totals is only about one barge load.

Table I-3

FY 78 Barge Shipments/Receipts of DFSC Fuel
(Gallons)

NWS Region	Shipped	Received
Lower Mississippi River	836,388	46,290,128
Arkansas River	-	2,588,826
Gulf Intracoastal Waterway - West	62,515,966	16,085,941
Gulf Intracoastal Waterway - East	126,021,066	123,930,097
South Atlantic Coast	126,066,552	128,746,970
Middle Atlantic Coast	412,772,328	367,822,950
New England	16,727,772	16,612,540
Great Lakes and New York State Waterways	14,980,299	57,308,503
Washington/Oregon Coast	87,803,445	123,538,643
California Coast	106,537,136	70,801,938
Alaska	4,441,060	4,441,060
TOTAL	958,701,952	958,167,596

SOURCE: Defense Fuel Supply Center records.

While all United States military bases have the capability to receive fuel by truck, and many are served by pipeline or rail, the installations noted in Exhibit I-1 can be served on a practical basis only by water. Essentially all coastal air and naval bases from Pensacola, Florida, to northern Maine, with some exceptions in the Hampton Roads and Washington, D.C. areas, are dependent on water transport because of the absence of product pipelines. Other installations requiring water service are on the New York State Canal and Lake Champlain, in Upper Michigan, the Puget Sound area, in western Alaska, and in Hawaii.

The general patterns of fuel movements by water have recently been fairly constant. Tanker movements are in Military Sealift Command-controlled shipping. Currently, MSC-operated ships include 18 medium tankers (9 Sealift class, 4 Falcon class, 5 T-5 class) and three small tankers of the T-1 type. Due to limited depths and relatively small demands at the ports used, MSC-operated tankers have capacities of 250,000 barrels or less, and drafts under 40

feet. An additional two commercial tankers are on time charter, and six more are under voyage charter. MSC tanker shipping patterns are:

1. Gulf Coast to Atlantic Coast.

2. Gulf Coast to Europe.

3. Caribbean to Atlantic Coast.

4. Caribbean to Europe.

5. Caribbean to Pacific Coast.

6. Along the Pacific Coast plus Alaska and Hawaii.

7. Greece to Norfolk.

8. Greece to Europe.

9. Greece to Subic Bay, the Philippines.

Tankers typically move fuel into distribution terminals, from which barges, pipelines, rail, or trucks move the products on to other installations. Major distribution terminals include: Jacksonville, Florida; Charleston, South Carolina; Morehead City, North Carolina; Norfolk, Virginia; Piney Point, Maryland; Port Reading, New Jersey; Melville, Rhode Island; Newington, New Hampshire; Mukilteo and Manchester, Washington; Point Molate, Stockton, and Point Loma, California; Kodiak, Alaska; and Pearl Harbor, Hawaii. Barge movements generally originate either at refineries or at DFSC distribution terminals, then move to nearby installations. All of the fuel movements within the Gulf Coast area are by barge.

Military general cargo movements through ocean terminals are the other major category of water shipments. Since the end of shipments to Vietnam in 1975, overseas military cargo shipments have been fairly stable. In FY 78, MTMC transshipped 7,003,650 measurement tons of cargo at CONUS water terminals. Exports comprised about 80% of the work load, reflecting both consumables

being sent overseas and military aid shipments. Approximately 22% of exports and 49% of imports were through military-owned terminals. Table I-4 provides a breakdown of commodity types handled. Containerization is now extensive, with 78% of all DOD-sponsored exports being containerized. Tables I-5 and I-6 indicate individual terminal work loads for ports on the Atlantic and Gulf Coasts (Eastern Area) and Pacific Coast (Western Area), respectively.

Current shallow-draft military traffic is almost entirely in petroleum products, with probably less than 2% of the traffic comprised of machinery movements such as jet engines. Petroleum movements by barge are concentrated in the Gulf Intracoastal Waterway, on coastal and estuary routes all along the Atlantic Coast, and in the Puget Sound and San Francisco Bay areas. Small amounts move on the Mississippi River system, the Great Lakes, and the New York State Canal system. Deep-draft traffic is primarily containerized cargo moving through major commercial ports, especially New York/New Jersey, Baltimore, Hampton Roads, New Orleans, Los Angeles/Long Beach, Oakland, and Seattle/Tacoma. Large amounts of cargo also move through military-controlled deepdraft terminals, including general cargo, petroleum products, and ammunition.

Table I-4

Cargo Commodities Transshipped through MTMC Ocean Terminals, FY 78(1)

Commodity	Tonnage (Thousands of Measurement Tons)	Percent
Intermodal Containers	4,518.1	64.5%
General Cargo	602.1	8.6
Privately Owned Vehicles	596.7	8.5
Government Vehicles (over 5 tons)	464.1	6.6
Personal Property	387.1	4.4
Government Vehicles (5 tons or less)	213.0	3.0
Ammunition	181.5	.6
Cargo Containers	52.2	0.8
Aircraft, Unboxed	43.7	0.6
Refrigerated Cargo	25.2	0.4
TOTAL	7,083.7	100.0%

NOTE: (1) Includes non-DOD-sponsored cargoes.

SOURCE: Military Traffic Management Command, AIF Cost Reports (RCS-MTMC-FM-16).

Table I-5

Cargo Transshipped by Facility
(Measurement Tons)

FY 78

MTMC Eastern Area

Type of Facility	Facility	MTONS Export	MTONS Import	MTONS Total
C(1)	Great Lakes Area	4,213	-	4,213
G	Davisville, Rhode Island	3,627	1,437	5,064
C	New England Area(2)	67,682	-	67,682
G	NWS Earle, New Jersey	42,364	3,273	45,637
G	MOT Bayonne, New Jersey	410,199	258,364	668,563
C	Other Piers, New York/ New Jersey	1,026,967	108,096	1,135,063
C	Philadelphia Area	61,325	1,351	62,676
C	Baltimore Area	411,220	5,488	416,708
G	NSC Norfolk, Virginia	1,938	89,204	184,142
G	NWS Yorktown, Virginia	1,928	-	1,928
G	Cheatham Annex, Virginia	179	-	179
C	Hampton Roads, Virginia	429,029	91,816	520,845
C	Morehead City, North Carolina	34,443	-	34,443
C	Wilmington, North Carolina	1,686	-	1,686
G	MOT Sunny Point, North Carolina	196,436	15,839	212,275
C	Charleston, South Carolina	196,159	81,269	277,428
C	Savannah, Georgia	53,796	5,625	59,421
C	Jacksonville and South To Include Key West, Florida	40,104	2,431	42,535
C	Mobile, Alabama	69,583	28,155	97,738
C	Other East Gulf Ports(3)	10,412	7,288	17,700
G	New Orleans Outport	276,355	169,184	445,539
C	New Orleans Port Area(4)	129,331	45,411	174,742
C	Beaumont, Texas	92,093	11,989	104,082
C	West Texas Ports(5)	15,940	3,651	19,591
C	Port Arthur, Texas	-	2,973	2,973
TOTAL Eastern Area		3,670,009	932,844	4,602,853

NOTES: (1) C - Commercial; G - Government.

NOTES: (Continued)

(2) Includes ports in Maine, Massachusetts, and Connecticut.

(3) Includes Pascagoula, Gulfport, Baton Rouge, Pensacola.

(4) Includes commercial New Orleans, St. Louis, Memphis.

(5) Includes Corpus Christi, Galveston, Houston.

SOURCE: Area Army Industrial Fund Cost Reports, RCS MTMC-FM-16.

Table I-6

Cargo Transshipped by Facility
(Measurement Tons)

FY 78

MTMC Western Area

Type of Facility	Facility	MTONS Export	MTONS Import	MTONS Total
C(1)	Navy Piers, Hunters Point, California	20	-	20
C	Stockton, California	-	8,379	8,379
C	San Francisco/ Oakland, California	1,198,915	161,797	1,360,712
G	NWS Concord, California	19,144	1,849	20,993
G	MOT Bay Area, Oakland, California	75,144	113,292	188,436
C	Long Beach, California	222,816	81,847	304,663
C	Wilmington, California	7,334	4,245	11,579
G	NSC San Diego, California	52,993	14,395	67,388
G	NCBC Port Heuneme, California	38,456	4,246	42,702
G	NAS North Island, California	291	-	291
C	Seattle, Washington	10,970	7,793	18,763
C	Tacoma, Washington	25,681	894	26,575
C	Portland, Oregon	-	19	19
C	Washington Area(2)	292,102	50,542	342,644
C	Oregon Area(2)	7,633	-	7,633
	TOTAL Western Area	1,951,499	449,298	2,400,797

NOTES: (1) C - Commercial; G - Government.
(2) Includes all ports in Washington and Oregon where vessel operator has loading or unloading responsibilities.

SOURCE: Area Army Industrial Fund Cost Reports, RCS MTMC-FM-16.

(b) Access to Naval Facilities

The United States Navy maintains a complex of shore facilities throughout the United States to support its fleet and air operations, although they are concentrated in the South Atlantic, Pacific Coast, and Hawaii. Major naval complexes are located at Hampton Roads (Norfolk/Portsmouth/Yorktown), Virginia; Charleston, South Carolina; Jacksonville and Pensacola, Florida; San Diego, California; San Francisco Bay (Alameda/Oakland/Concord/Mare Island), California; Puget Sound (Bremerton/Bangor/Whidbey Island/Seattle), Washington; and Pearl Harbor, Hawaii. Separate bases are provided for submarines at New London, Connecticut, and Kings Bay, Georgia, and for construction battalions at Gulfport, Mississippi, and Port Hueneme, California. Support installations which remain at former major naval bases include shipyards at Kittery, Maine (Portsmouth, New Hampshire), Philadelphia, Pennsylvania, and Long Beach, California; supply centers at New Orleans, Louisana, and Newport, Rhode Island; and a weapons station at Earle, New Jersey, in Monmouth Bay. Naval vessels also call at Key West, Florida, Adak, Alaska, and Roosevelt Roads, Puerto Rico.

Access to these facilities requires channel depths of 35 to 45 feet, with the greater depths required for submarines, aircraft carriers, and fleet tankers. Maintenance of these depths by dredging is required at those locations which are on rivers and in tidal estuaries, although periods between dredging vary considerably. The Puget Sound area requires almost no dredging, whereas Charleston, South Carolina, and Concord, California, require it frequently. The long-term outlook is for the further contraction of naval base locations as the fleet diminishes in size. Significant cutbacks have already occurred in the New England area and at Long Beach.

Access to commercial shipyards is also required since all naval vessel construction and a large portion of repair work is done at these facilities. Major United States shipyards and their locations are shown in Table I-7. Certain of the commercial shipyards are major

builders of naval vessels, and two have the only nuclear submarine building capabilities in the United States: General Dynamics, Electric Boat Division, and Newport News Shipbuilding. The latter is also the only yard able to construct nuclear-powered surface combatants.

Table I-7

Major United States Shipyards

Company	Locations
American Shipbuilding	Lorain, Ohio; Toledo, Ohio; Chicago, Illinois; Tampa, Florida (Nashville Bridge Division)
Avondale Shipyards	Avondale, Louisana(1)
Bath Iron Works	Bath, Maine(1)
Bay Shipbuilding	Sturgeon Bay, Wisconsin
Bethlehem Steel	Sparrows Point, Maryland; Beaumont, Texas
Boeing Marine Systems	Seattle, Washington(1)
Equitable Shipyards	New Orleans, Louisana
FMC Corporation	Portland, Oregon
General Dynamics	Quincy, Massachusetts; Groton, Connecticut (Electric Boat Division)(1)
Levingston Shipbuilding	Orange, Texas
Litton-Ingalls Shipbuilding	Pascagoula, Mississippi(1)
Lockheed Shipbuilding	Seattle, Washington(1)
Marinette Marine	Marinette, Wisconsin(1)
National Steel & Shipbuilding Co.	San Diego, California(1)
Newport News Shipbuilding and Drydock	Newport News, Virginia(1)
Norfolk Shipbuilding and Drydock	Norfolk, Virginia(1)
Peterson Builders	Sturgeon Bay, Wisconsin(1)
Southern Shipbuilding	Slidell, Louisana
Sun Ship	Chester, Pennsylvania
Tacoma Boatbuilding	Tacoma, Washington(1)
Todd Shipyards	San Pedro, California(1); Seattle, Washington(1)

NOTE: (1) Currently building vessels for United States Navy or United States Army Corps of Engineers.

SOURCE: Marine Engineering/Log, June 15, 1979.

Recent Congressional testimony by Everett Pyatt, Deputy Assistant Secretary of the Navy (Logistics) to the House Merchant Marine Subcommittee indicated that 15 to 19 of the existing 27 major shipyards would be needed in a future emergency. These shipyards should be scattered: five to six each on the Atlantic and Pacific coasts, four to five on the Gulf Coast, and one or two in the Great Lakes.[14] Other statements have indicated that without further commitments to new naval or merchant marine construction programs, the number of yards could shrink to eight by the mid-1980s. As evidence of this trend, Seatrain Shipbuilding in Brooklyn, New York, ceased operations on May 8, 1979, and Bethlehem Steel's Sparrows Point yard has been considered for closure.

(c) Current Problems

Telephone interviews were conducted with barge transportation managers in each of the five DFSC regions, plus tanker managers at DFSC and MSC. Corps field personnel were also contacted as part of the NWS visits. The single major problem noted was indequate channel depths due to deferred dredging. Tanker operations were most commonly affected, whereas most naval bases and military-owned general cargo facilities have adequate depths. The problem tends to occur in those locations where the military is the only user of the channel and traffic is at a relatively low level, or the facility is in standby for contingency usage. This entails a tradeoff between dredging costs and extra operational expenses within the DOD budget. Light loading of barges and tankers is required routinely at Port Mahon, Delaware (Dover AFB); Langley AFB, Virginia; Burlington, New Jersey (McGuire AFB); Key West, Florida; Tampa, Florida (MacDill AFB); Newington, New Hampshire (Pease AFB); New Haven, Connecticut (Westover AFB); Stockton, California; and Kodiak, Alaska. At Port Mahon and Langley AFB, dredging permits have been delayed for several years due to concern over oyster beds.

Several nonoperating problems were also noted with respect to fuel movements. DFSC has seen a long-term reduction in the number of refiners, barge companies, and pipelines willing to do business with DOD because the business involved is small, more profitable commercial

business is available, and payments are low. In addition, DFSC has barge cleanliness requirements more stringent than commercial standards, which has led to problems with equipment availability and cleaning costs.

On the Great Lakes, one common carrier (Cleveland Tankers, with five ships) and one private carrier (Amoco Oil, with two ships) are the only companies that will work with DFSC. In the San Francisco area, there is only one company (Coastal Towing & Lighterage) which has clean product barges in its fleet. The New York State Canal system requires specialized equipment and depths limit loads to 15,000 barrels instead of 18,000 barrels capacity; however, equipment availability is not a problem.

(d) Dredging Activities for the Department of Defense

Current procedures regarding the allocation of channel maintenance costs require the military to provide funding for those features attributable to military requirements, which are over and above the requirements of commercial users. Information on channel maintenance projects performed for the military was obtained for the United States Army Corps of Engineers' Division Offices. Exhibit I-2 summarizes the information received. Total annual dredging volumes are under 7.0 million cubic yards, although special projects can increase the work load in certain years.

Most DOD dredging projects are limited to the maintenance of approach channels and pierside areas; special projects are performed on a cost sharing principle, with a fixed percentage of costs borne by the military. Such locations are Canaveral Harbor, Florida, the St. Mary's River in Georgia and Florida, Channel Island's Harbor, California, and Oceanside Harbor, California. Dredging requirements in Exhibit I-2 for these locations are the military share only. Department of Defense dredging needs are generally a very small portion of total United States dredging requirements, and are limited to certain naval bases and military-owned terminals.

NATIONAL WATERWAYS STUDY, ELEMENT E/F

MAJOR MILITARY INSTALLATIONS RELIANT ON WATER DELIVERIES OF FUEL

Military Installation	Serving Terminal	Terminal Location
NAS Pensacola	On Base(1)	Pensacola, Florida
Eglin AFB	On Base (1)	Valparaiso, Florida
Tyndall AFB	DFSP Lynn Haven(1)	Lynn Haven, Florida
MacDill AFB	On Base	Tampa, Florida
NAS Key West	On Base	Key West, Florida
Homestead AFB	DFSP Fort Lauderdale	Fort Lauderdale, Florida
USN Facilities, Jacksonville Area	DFSP Jacksonville(2)	Jacksonville, Florida
MCAS Beaufort	On Base(1)	Beaufort, South Carolina
USN and USAF Facilities, Charleston Area	DFSP Charleston	North Charleston, South Carolina
USMC Facilities, Camp Lejeune Area	DFSP Morehead City	Morehead City, North Carolina
MCAS Cherry Point	On Base (1)	Cherry Point, North Carolina
Seymour Johnson AFB	On Base (3)	Goldsboro, North Carolina
Langley AFB	On Base(1)	Hampton,Virginia
Virginia ANG, Byrd Field	On Base(1)	Sandstone, Virginia
NAS Patuxent River	On Base(1)	Lexington Park, Maryland
Dover AFB	DFSP Port Mahon(1)	Port Mahon, Delaware
McGuire AFB	DFSP Burlington(1)	Burlington, New Jersey
Grifiss AFB	On Base(1)	Rome, New York
Plattsburgh AFB	On Base(1)	Plattsburgh, New York

NATIONAL WATERWAYS STUDY,
ELEMENT E/F

MAJOR MILITARY INSTALLATIONS
RELIANT ON WATER DELIVERIES OF FUEL

Military Installation	Serving Terminal	Terminal Location
Vermont ANG	On Base(1)	Burlington, Vermont
Westover AFB	DFSP New Haven	New Haven, Connecticut
NSC Newport	On Base	Newport, Rhode Island
USN and USAF Facilities, Portsmouth Area	DFSP Newington	Portsmouth, New Hampshire
NAS Brunswick	DFSP Casco Bay	Harpswell Neck, Maine
Loring AFB	DFSP Searsport	Searsport, Maine
Wurtsmith AFB	DFSP Harrisville	Harrisville, Michigan
K.I. Sawyer AFB	DFSP Escanaba	Escanaba, Michigan
NAS Whidbey Island	On Base	Oak Harbor, Washington
USN Facilities, Bremerton Area	DFSP Puget Sound	Manchester, Washington
NCBC Port Hueneme	On Base	Port Hueneme, California
Adak Naval Station	On Base	Adak, Alaska
Shemya AFB	On Base	Shemya, Alaska
USN and USAF Facilities, Oahu Island	Pearl Harbor Naval Station	Pearl Harbor, Hawaii

NOTES: (1) Barge service only.
(2) NAS Jacksonville and the Mayport Naval Base are served only by barge.
(3) Also served via rail from DSFP Morehead City.

SOURCE: Defense Fuel Supply Center and NWS Analysis

ESTIMATED DREDGING REQUIREMENTS FOR THE DEPARTMENT OF DEFENSE

Activity	Estimated Volume (Cubic Yards)	Dredging Frequency
Army Outport, New Orleans, Louisana	Minor	(1)
Naval Air Station, Pensacola, Florida	200,000	Annually
Canaveral Harbor, Florida (2)	400,000	Annually
Naval Air Station, Mayport, Florida	1,200,000	Annually
Submarine Base, Kings Bay, Georgia	750,000	Annually (3)
Naval Complex, Charleston, South Carolina	700,000	Annually (4)
Military Ocean Terminal, Sunny Point, Southport, North Carolina	1,000,000	Annually
Naval Complex, Norfolk, Virginia	850,000	Annually
Naval Weapons Station, Yorktown, Virginia	545,000	(1)
Fort Eustis, Newport News, Virginia	10,000	(1)
Langley Air Force Base, Hampton, Virginia	52,000	(1)
Naval Shipyard, Philadelphia, Pennsylvania	400,000	2 Years
Naval Weapons Station, Earle, New Jersey	1,157,000	(5)
Submarine Base, New London, Connecticut	4,000,000	(6)
Portsmouth Naval Shipyard, Kittery, Maine	100,000	(7)
Naval Air Station, Alameda, California	750,000	Annually
Naval Supply Center, Oakland, California	125,000	2-3 Years
Military Ocean Terminal, Bay Area, Oakland, California		
(north side)	80,000	6-10 Years
(east side)	120,000	3 Years
Defense Fuel Supply Point, Point Molate, California	228,000	2-3 Years

ESTIMATED DREDGING REQUIREMENTS FOR THE DEPARTMENT OF DEFENSE

Activity	Estimated Volume (Cubic Yards)	Dredging Frequency
Mare Island Naval Shipyard and Support Activity, Vallejo, California	1,250,000	Semiannually
Naval Weapons Station, Concord, California	50,000	2 Years
Naval Construction Battalion Center Port Hueneme, California (Channel Islands Harbor)	475,000	Semiannually
Camp Pendleton, California (Oceanside, Harbor)	150,000	Annually

NOTES:
(1) Activity is infrequent; volume shown is for most recent work.
(2) Covers military usage of NASA facilities at Kennedy Space Center.
(3) Excludes work recently completed to deepen the existing channel for Trident submarines.
(4) Cooper River Diversion Project, due to be completed in 1984, will reduce annual requirements significantly.
(5) Total for special work done in 1978-1979 for homeporting of AE-type support ships. Project totaling 11 million cubic yards is contemplated in 1984-1985 for AOE-type ships.
(6) Total for special work done over five years for Trident submarines; maintenance dredging is minimal.
(7) Total for special work done over two years; maintenance dredging is minimal.

SOURCE: United States Corps of Engineers.

II - MILITARY CONTINGENCY WATERWAYS REQUIREMENTS

NATIONAL DEFENSE EMERGENCY WATERWAYS PLANNING

(a) General Concepts

Experience from World War II and the Korean Conflict demonstrated that maintenance of national emergency preparedness was needed for quick transition from peacetime to wartime. Accordingly, the Congress authorized development of emergency preparedness programs within the federal government. Overall coordination and direction of these programs is the responsibility of the Federal Emergency Management Agency (FEMA). Executive Order 11490, as amended, is the presidential directive assigning emergency preparedness functions to federal departments and agencies. These agencies are to work closely with state and local governments and with private industry to develop their emergency preparedness plan and programs.

National defense plans, programs and operations are the responsibility of the Department of Defense (DOD) and FEMA. Assignments of emergency functions to other federal agencies are on the basis of resources related to the basic mission and capabilities of the agency. All agencies are required to plan for continuity of government, but under E.O. 11490 certain named agencies must prepare national emergency plans, develop preparedness programs, attain an appropriate state of readiness, and be prepared to implement their emergency plans.[15] Upon declaration of a national emergency by the President or the Congress, designated resource agencies will assume responsibilities for the allocation of specified resources, while other agencies will directly supervise the operations of specified industries or services under the auspices of the resource agencies.

Emergency resource allocation authority for civil transportation has been assigned to the Department of Transportation, while the Department of the Interior has been assigned a similar authority for water resources.

Other agencies with resource allocation authority relevant to navigation, at least indirectly, are [16]:

1. Food, Fertilizer and Farm Equipment - the Department of Agriculture.

2. Petroleum and Natural Gas - the Department of Energy (Emergency Petroleum and Gas Administration).

3. Coal - the Department of Energy.

4. Minerals - the Department of the Interior (Emergency Minerals Administration).

5. Electric Power - the Department of Energy (Emergency Electric Power Administration).

6. Manpower - the Department of Labor.

7. Telecommunications - the Federal Communications Commission.

8. Defense Supply System - the Department of Defense.

9. Other Industrial Production - the Department of Commerce.

During a national emergency, existing relationships and operations will continue to the extent practical. However, the resource allocation agencies will receive forecasts of requirements and capabilities from industries and control agencies within their area of responsibility. The requirements are considered "claims" for a resource, with the submitting agency considered a "claimant". Resource agencies will resolve claimancy requirements on the basis of priorities, capabilities, and overall emergency directions, and will turn to FEMA for resolution of conflicts between resource agencies.

(b) Navigation

During peacetime, the Office of Emergency Transportation is the emergency planning and coordination organization for the Department of Transportation. Upon

declaration of a national defense emergency, this office will be the nucleus of the National Emergency Transportation Center (NETC), which will be the resource agency for all civil transportation. All civil facilities, including terminals, warehouses, etc., used to provide an intercity service, are within the scope of the NETC, whether private, common carrier, or contract in type, and interstate or intrastate in nature. Excluded are military transportation and all local or metropolitan civilian transportation systems.[17]

Organization of the NETC is along modal lines, although intermodal direction, guidance, and controls may be issued as appropriate. Other agencies or other components of DOT exercise control authority over various segments of the transportation industry. Table II-1 indicates the transportation operating agencies whose emergency functions are related to water transportation, and who must coordinate their operations through the NETC. Assistance in operating the transportation system during an emergency is received from the transportation support agencies noted in Table II-2.

Table II-1

Emergency Transportation Operating Agencies

Agency	Responsibilities
Federal Highway Administration	Ensure availability of highways. Regulate highway motor vehicle traffic.
Department of Commerce, Maritime Administration	Procure and control merchant ocean shipping, ocean ports, and associated port facilities. Administer the movement of cargo and passengers through port areas. Maintain the National Defense Reserve Fleet.
Interstate Commerce Commission	Coordinate and direct operation of motor carriers, railroads, inland waterway shipping (including domestic Great Lakes traffic), freight forwarders, and public storage.
Department of Defense, Military Sealift Command	Operate merchant and military ocean shipping.
Department of Defense, Military Traffic Management Command	Procure and operate military port facilities. Provide traffic management for DOD.
Department of Energy (Emergency Petroleum and Gas Administration	Coordinate and direct operation of petroleum and natural gas pipelines.

SOURCE: United States Department of Transportation, Emergency Procedures for the Control of Civil Transportation.[17]

Table II-2

Emergency Transportation Support Agencies

Agency	Responsibilities
United States Coast Guard	Maritime safety and law enforcement. Port area security.
United States Army Corps of Engineers(Civil Works)	Operate, improve, restore and maintain components of federal navigation projects. Locate and remove navigation obstructions.
Tennessee Valley Authority	Manage the Tennessee River navigation system.
St. Lawrence Seaway Development Corporation	Operate and maintain United States controlled sections of the St. Lawrence Seaway.

SOURCE: United States Department of Transportation, Emergency Procedures for the Control of Civil Transportation.[17]

DOT has planned for the implementation of eight emergency field offices. They are to provide direct assistance to the field elements of the federal claimants, and federal operating and support agencies, in implementing national transportation policy guidance, directives, and controls. In the event of regional isolation, the field offices would act for the NETC. An additional function of the field offices is to maintain liaison with state and local governmental agencies, who will be directing all intrastate and local transportation services. One DOT field office is designated for each Office of Emergency Preparedness region.

Inherent in the emergency civil transportation plan is decisionmaking at the lowest practical level. Yet, serious time lags may occur in many conflicting demand

situations. An example of the potential problem is illustrated by the procedure the Defense Fuel Supply Center (DFSC) would follow to arrange an inland barge movement. Under 37 CFR Chapter I, Part 177, the internal DOD procedures would be as follows:

1. Point-to-point movement requirements are projected and priorities established by DFSC, then forwarded to the Military Traffic Management Command (MTMC).

2. MTMC receives requirements from all traffic managers, and submits the consolidated transportation requirements and an analysis of shortfalls with recommended actions to the Joint Chiefs of Staff (JCS).

3. The JCS reviews DOD transportation requirements and submits them with appropriate recommendations to the appropriate Assistant Secretary of Defense.

4. The Assistant Secretary of Defense (Manpower, Resource Affairs, and Logistics) (ASD/MRA&L) validates short-term requirements from the JCS in accordance with national program priorities. Matters affecting DOD strategic mobility are coordinated with the Assistant Secretary of Defense (Program Analysis and Evaluation) (ASD/PA&E). ASD/MRA&L submits all requests for civil transportation to DOT. The ASD/PA&E analyzes, validates and submits long-term requirements to ASD/MRA&L for subsequent submission to DOT.

5. The Department of Transportation allocates civilian transport resources to DOD based upon projected capabilities and overall FEMA guidance and priorities.

6. Upon receipt of alloted capabilities from DOT, the ASD/MRA&L transmits allocations to the JCS, along with guidance on procurement and related comments.

7. The JCS determines the relative urgency of the DOD requirements and suballocates capabilities among them.

8. MTMC then manages the movement of the cargo in accordance with priorities.

9. In certain cases, DFSC manages its own cargo movements after receiving clearance from MTMC.

DOT will be receiving transportation requirements from all claimant agencies, while the transportation operating agencies will be measuring modal capabilities for DOT. Allocations will be made on the basis of National Objectives statements prepared by FEMA. Submission of requirements and capabilities will be due by the seventh day of the month preceding the time period it will be effective for all modes, except ocean, coastwise, and Great Lakes traffic. For this water traffic, submissions will be due by the seventh day of the second preceding month.

The entire process depends upon good estimates of requirements and capabilities well in advance of the time of demand, although urgent requests will certainly occur. A reasonable conclusion is that the system for allocating civil transportation will prove to be cumbersome and slow to respond.

With regard to the waterways system, there is a notable division of operations responsibilities among agencies.

1. For inland navigation, the ICC will control the carriers (common, contract or private) and ports; the Corps of Engineers will operate and maintain the navigation system (on the Tennessee River they will be under the direction of the TVA); and the Coast Guard will continue its safety and security programs.

2. For ocean shipping, including intercoastal and foreign Great Lakes traffic, the Maritime Administration will manage the carriers and ports; the Corps will maintain the channels, except for the St. Lawrence Seaway, which will be managed by the Seaway Development Corp.; the Military Sealift Command will operate certain ships; and the Military Traffic Management Command will operate certain ports. Note that domestic Great Lakes traffic is managed by the ICC, and MARAD will operate all ports.

3. Other allocation agencies which will exercise influence over the waterways transportation system include Interior for water resources (regulation of channel flows); Commerce for the construction of vessels, towboats and port facilities; Energy for fuel; Labor for manpower and training; and the FCC for communications equipment.

DIRECT DEPARTMENT OF DEFENSE USAGE

During a major military contingency, the principal uses of the waterways system by the Department of Defense will be waterborne military cargo moves and United States Navy fleet support. Historically, personnel movements were accomplished primarily by oceangoing passenger ships, but current planning now envisions essentially all troop movements by aircraft.

(a) Unit Deployments and Cargo Resupply

An MTMC study of inland waterways [13] provides a recent unclassified analysis of potential contingency requirements. The analysis was based upon information contained in classified contingency plans, including the Joint Strategic Capability Plans (JSCP), JCS Strategic Mobility Requirements and Programs (SMRP), and Defense Logistics Agency plans. The study findings were:

1. JSCP does not specify the use of inland waterways for the movement of DOD cargo or units.

2. The recently completed SMRP, although detailed in both unit movement and follow-on supply movement requirements, does not specify use of the inland waterways as either a primary or alternate shipment means.

3. While SMRP uses rail and highway for CONUS surface movements, neither mode is taxed beyond its capability in peak periods.

4. Assuming completion of planned DOD ammunition port enhancements, alternative ammunition loading sites on inland rivers are not needed to meet planned movements.

5. Defense Logistics Agency (DLA) depots have no specific plans to use the inland waterways during contingency situations.

6. There are no DLA locations served by inland waterways for which alternative modes are not practical.

The report summary also notes that there is no order specifying that inland waterways should be considered when planning contingency unit or follow-on cargo movements. Figure II-A from that report depicts the typical East-West routings of such movements, in contrast to the generally North-South orientation of the inland waterways.

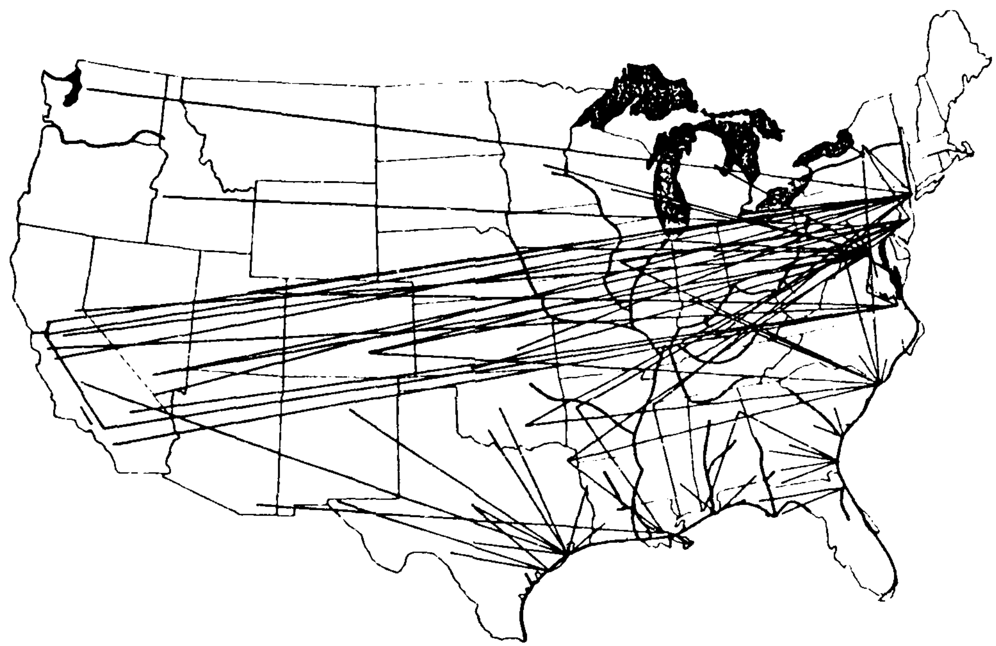
Table II-3 specifies those military installations with at least the potential to employ the shallow-draft inland waterways for unit or cargo movements. However, interviews with the Corps of Engineers and navigation chart analysis indicate that only four of these installations have an on-base capability to ship by the inland waterways. Furthermore, it is clear that DOD will be containerizing a major portion of its cargo, simply because of the high proportion of containerships in the United States and allied fleets.

Although LASH and SEABEE barges could be moved inland, the limited number of ships available and their high demand for moving unit equipment reduces the prospects for much traffic inland. In addition, transit time is a major factor in deployment moves, and cargo will tend to move on routes which offer the least total movement time, placing Gulf Coast ports in an unfavorable position. Waterways leading to the Gulf Coast are further constrained by the presence of Cuba near major shipping lanes. Given these drawbacks, and the likelihood that other modes will not be overtaxed, there is very little probability that shallow-draft inland waterways shipments by the military would be significant during a future contingency.

A recent study by MTMC [18] addresses deep-draft port capability to handle United States Army unit deployments at several commercial and military terminals. The study concluded that almost all of the sixteen port areas studied had adequate facilities to support the separate deployment of division-size units within a five-day port clearance constraint. It was found that only one combination of units and ships at Beaumont, TX, would be delayed, and then only by one day. Although many of the predesignated berths in the port areas were inadequate to support the deployments, other facilities were available which would be sufficient.

Figure II-A

Typical Routing for Contingency Deployment and Follow-On Supply Movements



SOURCE: An Analysis of CONUS Inland Waterways for National Defense, MTMC Report OA 77-11 [13]

Table II-3

Potential Contingency Shipping Locations on Inland Waterways

NWS Region	Installation	Location
Upper Mississippi	Twin Cities Army Ammunition Plant	New Brighton, MN
	Northern Ordnance Plant	Minneapolis, MN
	Savanna Deport Activity	Savanna, IL
	Rock Island Arsenal	Rock Island, IL
	Iowa Army Ammunition Plant	Burlington, IA
Lower Upper Mississippi	Installation Support Center	Granite City, IL
Lower Mississippi	Defense General Supply Center	Memphis, TN
Illinois River	Joliet Army Ammunition Plant	Joliet, IL
Missouri River	Fort Leavenworth	Fort Leavenworth, KS
	Lake City Army Ammunition Plant	Independence, MO
Ohio River	Naval Ordnance Station, Louisville	Louisville, KY
	Fort Knox	Louisville, KY
	Indiana Army Ammunition Plant	Charleston, IN
	Lexington Depot Activity	Lexington, KY
Tennessee River	Fort Campbell	Clarksville, KY
	Volunteer Army Ammunition Plant	Chattanooga, TN
	Redstone Arsenal	Huntsville, AL
	Phosphate Development Works	Sheffield, AL
Arkansas River	Fort Chaffee	Fort Smith, AR
	Pine Bluff Arsenal	Pine Bluff, AR
Gulf Coast East	Fort Benning	Columbus, GA
Middle Atlantic Coast	Watervliet Arsenal	Watervliet, NY
New York State System	Seneca Army Depot	Romulus, NY
Columbia River	Umatilla Depot Activity	Hermiston, OR

Source: NWS analysis.

Several DOD studies have indicated that there are no port limitations which will restrict DOD supply cargo movements. The one exception is ammunition, for which an improvement program is currently being undertaken. This conclusion was confirmed by interviews with MARAD and MTMC cargo movement planning staff. Planning is oriented towards the identification of those facilities which will best match the types of ships that will be used in contingencies, especially roll-on/roll-off vessels. The major constraints facing defense planners are the size, composition and availability of merchant ships, and the convoy escort/antisubmarine warfare capabilities of the United States Navy.

In addition to the ports identified in Tables I-5 and I-6, general cargo could also be moved through government-owned facilities at the Naval Supply Center, Seattle, Washington; Rough-and-Ready Island at Stockton, California (in conjunction with the Defense Depot at Tracy and Sharpe Army Depot at Stockton); the Naval Supply Center at Oakland, California; and the Depot Activity at North Charleston, South Carolina. The Defense General Supply Depot at Richmond, Virginia, could utilize the nearby Port of Richmond, and the Detroit Tank Arsenal at Warren, Michigan, could use the Port of Detroit. A stand- by ammunition terminal exists at Kings Bay, Georgia, where the United States Navy is developing a base for Trident submarines. This ammunition loading capability would be called into use during a contingency.

One factor not addressed in any of the cited studies is the threat posed to ports by Soviet ballistic missiles. Soviet naval strategy recognizes that the majority of NATO's strategic reserves must transit 3,000 miles of ocean, and that the destruction of ports, especially container handling facilities, can disrupt the sea lines of communication. Thus, a surplus of port facilities in the United States is a strategic asset. With destruction of port facilities possible by missiles, there should be a capability to rebuild or repair such damages.

In summary, current planning envisions the use of existing military and commercial ports to handle the majority of contingency cargo movements. The only inactive

facilities which might be utilized are at Kings Bay, Georgia, and Stockton, California. The primary national defense requirement within the scope of the NWS is to maintain access to these deep-draft terminals, and to be prepared to repair damaged facilities as directed.

(b) Access to Key Naval Facilities

General observations on present facility access needs are applicable to contingency requirements, because there are no plans to activate standby facilities or build new ones. Likewise, current shipbuilding and repair capabilities are adequate for anticipated contingency requirements. Thus, current and contingency requirements are the same.

MOVEMENT OF STRATEGIC MATERIALS

Under authority of the Strategic and Critical Materials Stockpiling Act, as amended (50 U.S.C. Sections 98-98h), the Federal Emergency Management Agency has been delegated the responsibilities for stockpile policy and planning, procurement, maintenance, management of storage site operations, and sales of excess materials. Stockpile policies originally announced on October 1, 1976, give first priority to acquisitions of materials needed to develop a strong readiness posture for the first year of a national emergency. Key elements of previous policy still in effect are:

1. Stockpile planning is based on United States requirements during the first three years of a major war.

2. Significant austerity measures will be taken as necessary within the national economy during wartime to sustain defense production.

Stockpile goals represent the estimated difference between supply and requirements to meet national security needs, as estimated under a given set of planning factors.

Ninety-three materials are maintained in the stockpile at 116 locations:

- 34 Military Depots
- 28 GSA Depots
- 16 Other Government-Owned Sites
- 10 Leased Commercial Sites
- 28 Industrial Plant Sites.

Government inventories contain stockpile and nonstockpile grade materials. Nonstockpile grade materials are sometimes credited to stockpile goals, although most are excess. Many of the nonstockpile grade materials were acquired by transfer of government-owned surpluses to the stockpile after World War II. Some materials were of stockpile grade when acquired, but no longer qualify because of changes in industry practices and technological advances. Other nonstockpile grade materials were acquired through Defense Production Act purchase programs.[19]

A review of stockpile material records indicates that only a few commodities are of such type and held in sufficient volume to be considered candidates for water transportation during a defense emergency. These are alumina and bauxite, chromite ore, ferroalloys, fluorspar, lead, manganese, and zinc. The National Waterways Study received records from FEMA for these materials, giving storage location, grade of material, and inventory amounts as of December 31, 1979. Revised stockpile goals announced May 2, 1980 by the President are cited in following sections.[20].

Analysis indicates that all of the strategic materials which are candidates for water movement are associated with either the aluminum, or iron and steel industries. Refractory materials (bauxite and chromite), special chemical raw materials, and storage battery materials (lead and manganese oxide) are not likely to be shipped by water, because the producing plants are not located on the

waterways and because the tonnages moving to any given plant site would be small. Materials which are likely to move on the waterways during a contingency will be discussed with respect to the using industry.

(a) Aluminum Industry

Bauxite is the principal ore from which aluminum is produced, and is a mixture of aluminum oxide minerals and impurities, such as iron oxides, aluminum silicates, and titanium oxides. Impurities are removed from bauxite ore using the Bayer process, with the final product being alumina (aluminum oxide) in dry powder form. Primary aluminum is produced by the electrolysis of alumina in a molten bath of natural or synthetic cryolite. This process requires two separate types of refining plants, which are not necessarily colocated.

The structure of the United States aluminum industry is shown in Figure II-B. Domestic alumina production is concentrated on the Gulf Coast and in Arkansas. Primary aluminum production locations are more widespread, and are strongly influenced by the availability of inexpensive electric power.

Metallic grade bauxite stockpiles are of two types, Jamaica and Surinam, which have differing chemical compositions. Bauxite produced in the United States has a much higher silica content than imported types. About 85% of domestic production is in Arkansas, and the two alumina refineries in that state are the only ones able to efficiently refine domestic bauxite. About 90% of total United States bauxite consumption is supplied by imports. National stockpile goals are for 21,000,000 long dry tons (LDT) of Jamaica-type bauxite and 6,100,000 LDT of Surinam-type bauxite.

The entire 8,858,881 long dry ton inventory of Jamaica-type bauxite is stored at the four alumina refineries where the ore is typically used. Of the 5,299,597 LDT of Surinam-type bauxite, a total of 917,863 LDT (17.3%) is stockpiled at plants in Texas. Another

3,128,172 LDT (59.0%) of Surinam-type bauxite is stockpiled at three government sites in the Gulf Coast area at Baton Rouge, Louisiana, near Mobile, Alabama, and Gulfport, Mississippi. Adding the other potential stockpiles noted in Table II-4, over two-thirds of the Surinam-type bauxite can be expected to move by water.

The remaining metallic grade bauxite inventory of 819,283 LDT is at two depots which are near proposed waterways: the Red River Army Depot in Texas is near the Red River, and the Anniston Army Depot in Alabama is near the Coosa River. Further, the Arkansas alumina refineries are close to the upper reaches of a proposed extension of the Ouachita River. If completed as proposed, these waterways could provide service for bauxite movements during contingencies. Current bauxite movement patterns into the Arkansas refineries through the Port of Little Rock would continue.

Figure II-B

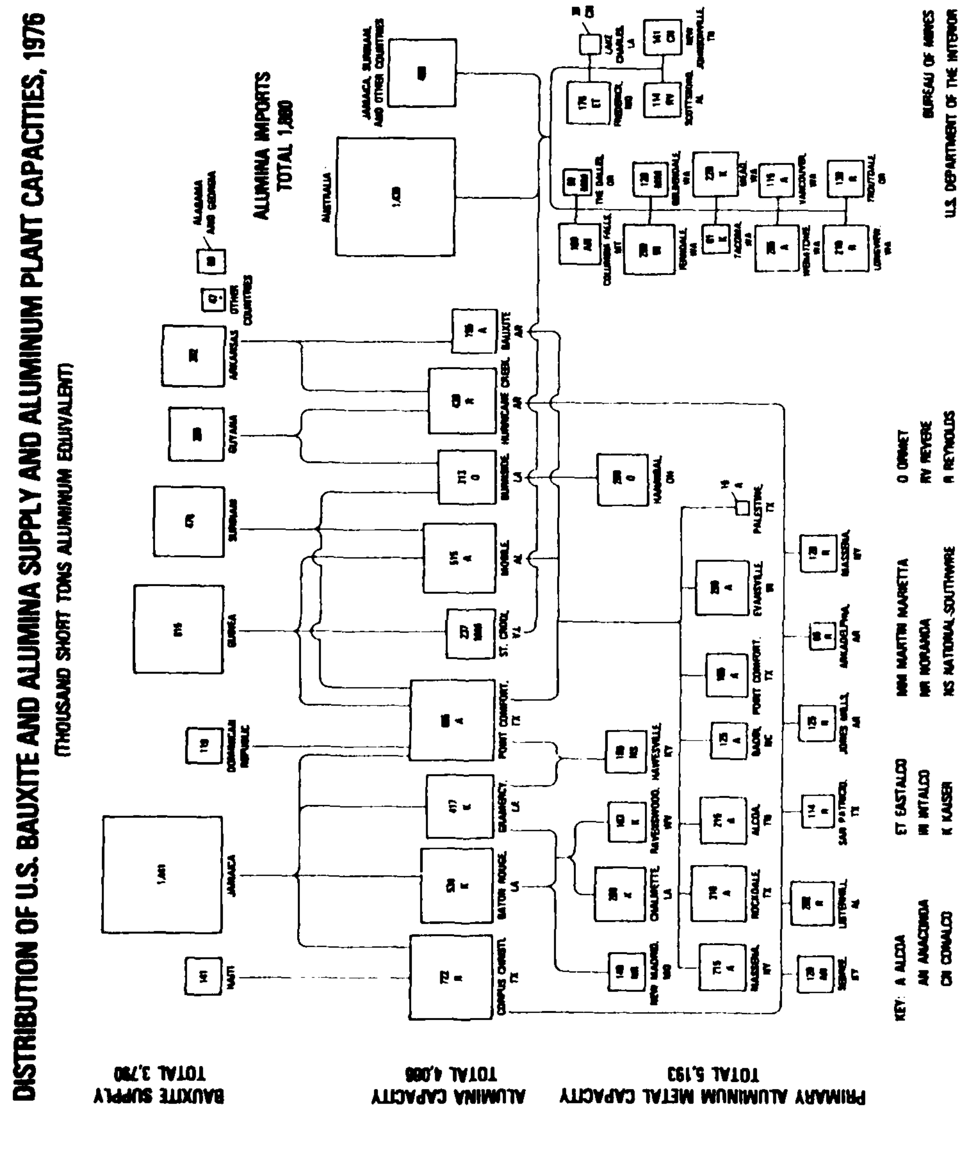

DISTRIBUTION OF U.S. BAUXITE AND ALUMINA SUPPLY AND ALUMINUM PLANT CAPACITIES, 1976
(THOUSAND SHORT TONS ALUMINUM EQUIVALENT)
BAUXITE SUPPLY TOTAL 3,780
ALUMINA CAPACITY TOTAL 4,088
PRIMARY ALUMINUM METAL CAPACITY TOTAL 5,193
ALUMINA IMPORTS TOTAL 1,880
KEY: A ALCOA
AN ANACONDA
CN CONALCO
ET EASTALCO
IN INTALCO
K KAISER
MM MARTIN MARIETTA
NR NORANDA
NS NATIONAL SOUTHWIRE
O ORMET
RV REVERE
R REYNOLDS
BUREAU OF MINES
U.S. DEPARTMENT OF THE INTERIOR

Table II-4

Potential Origins of Stockpiled Aluminum Industry Materials Moving by Water

Material	Location	Inventory(1)
Bauxite	Installation Support Activity, Granite City, Illinois	339,526
	Defense Depot Memphis Memphis, Tennessee	56,663
	GSA Depot, Baton Rouge, Louisiana	695,499
	Redstone Arsenal, Huntsville, Alabama	29,653
	Pine Bluff Arsenal, Pine Bluff, Arkansas	8,437
	GSA Depot, Theodore, Alabama	1,341,452
	Naval Construction Battalion Center Gulfport, Mississippi	1,091,221
BAUXITE TOTAL		3,562,451 LDT
Fluorspar	Wilmington Marine Terminal, Wilmington, Delaware	141,316
	GSA Depot, Curtis Bay, Maryland	23,254
	Defense Depot Memphis Memphis, Tennessee	137,699
FLOURSPAR TOTAL		302,269 SDT

NOTE: (1) Bauxite is measured in long dry tons, fluorspar in short dry tons.

SOURCE: Federal Emergency Management Agency.

Besides the imported bauxite refined at domestic alumina plants, another 35% of domestic alumina consumption is imported, primarily for refineries in the Pacific Northwest. During a contingency, alumina would be refined from stockpiled bauxite at Gulf Coast refineries and from

domestic bauxite in Arkansas. These sources could ship alumina to nearby aluminum refineries, as well as supply refineries in Texas and the Ohio and Tennessee river valleys. Most of these alumina movements could be by water.

A major unknown factor is alumina supplies for Pacific Northwest refineries. Domestic sources could ship via rail or deep-draft ships to keep these refineries operating, foreign sources could continue supplying them, or production would be cut back. It appears generally that stockpile-derived alumina movements by water will be extensive on the Mississippi, Ohio, Tennessee and Arkansas rivers, and on the Gulf Intracoastal Waterway.

Acid-grade fluorspar is the main raw material for hydrofluoric acid, which is used to produce products important in primary aluminum refining. They are aluminum fluoride and synthetic cryolite, produced by reacting hydrofluoric acid with alumina and caustic soda, respectively. Subsequently, cryolite and aluminum fluoride are used with alumina in the molten bath, from which aluminum is produced by electrolysis. This process permits cryolite and fluorosilicic acid to substitute for fluorspar.

Fluorspar is converted into hydrofluoric acid at 12 domestic plants operated by eight companies. A secondary source of domestic fluorine for the aluminum industry is by-product fluorosilicic acid recovered at phosphoric acid plants. Federal stockpiles of acid grade fluorspar and cryolite total 895,391 short dry tons (SDT), against a goal of 1,400,000 SDT. However, 352,783 SDT of acid grade fluorspar and cryolite have been applied against the metallic grade objective of 1,700,000 SDT; the metallic grade stockpile is 294,875 SDT.

Potential acid grade fluorspar movements by water are small. Of the stockpiles not applied to the metallic grade objective, 302,269 SDT (55.7%) are at water-served locations. Hydrofluoric acid plants at North Claymont, Delaware, and Paulsboro, New Jersey, could receive fluorspar from Curtis Bay, Maryland, and Wilmington, Delaware, by water. The stockpile at Memphis, Tennessee, could move to any of eight acid plants on the Gulf Intracoastal Waterway, Mississippi River, and Kanawha River.

During a contingency, the movement of bauxite and alumina on the waterways can be anticipated to be extensive, especially since production will tend to be principally at plants on the Gulf Coast and the Mississippi River tributaries. Other materials used on the aluminum industry can also be expected to move to some degree on the waterways system.

(b) Iron and Steel Industry

Ferroalloys are used to produce distinctive qualities in steel and cast irons, with the principal types being alloys of manganese and silicon. Manganese is used in the production of nearly all steel, primarily to neutralize sulfur. It also imparts certain characteristics to steel, but other materials can be substituted for this use. Manganese metal is used as an alloy with aluminum and magnesium, as well as in manganese bronzes which are used in ship propellers.

The only domestic commercial source of manganese is from ferruginous manganese ores or concentrates containing 10% to 35% manganese from the Cuyuna Range of Minnesota. Manganese production in Arkansas under government contract ceased in 1959. Essentially all requirements are met with imports of manganese ore and ferromanganese. For this reason manganese ore and manganese alloys are stockpiled by FEMA. Silicon alloys are used primarily for deoxidation during steelmaking, but the United States can be self-sufficient in this material even though imports are about 20% of consumption.

Other major ferroalloys, ranked by level of consumption, are ferrochromium, ferronickel, ferrophosphorus, ferrotitanium, ferromolybdenum, ferrovanadium, ferrocolumbium, ferroboron, and ferrotungsten. The ferroalloy industry is closely associated with the steel and aluminum industries. In 1976 there were 26 producers of ferroalloys (other than ferrophosphorus) operating 43 plants. Another seven producers with 10 plants produced ferrophosphorus. A long-term trend has been toward small annual reductions in industry capacity, with the integrated steel companies closing their own furnaces and

relying on suppliers. Proximity to steel and aluminum plants, along with availability of electricity, have been the major factors affecting plant location.

Chromium, used primarily as an alloy in stainless steel, is obtained from chromite ore. There has been no domestic production of chromite since 1961, when the last government Defense Act contract ended. Both chromite ore and chromium alloys are stockpiled. Other stockpiled ferroalloys include ferrocolumbium, ferrotungsten and ferrovanadium. The United States can be self-sufficient in ferrosilicon and ferrophosphorus, although imports are about 20% of the former. Of the stockpiled materials, only chromium and manganese alloys are held in sufficient amounts to justify water movements. Within these two groups there were eight companies operating 13 ferrochrome plants, and nine companies operating 12 plants, for ferromanganese or silicomanganese at the end of 1976.[21]

Although zinc is the third most-used nonferrous metal, it is not often used directly. Its primary uses are for galvanizing steel, as an alloy in brass and bronzes, in castings, and as zinc oxide for various chemical applications. Zinc metal is also used as a sacrificial anode to protect ships, and as an alloy with aluminum and magnesium. Domestic ores provided 68% of total United States production in 1976, with secondary recovery adding another 11%. Imports accounted for the remainder of domestic ore consumption. Metallic zinc imports filled over 42% of total domestic demand. Canada is the largest supplier of zinc ores and metal.

Fluorspar is important to metal production, acting as a fluxing agent in steelmaking and as a feedstock for the producion of hydrofluoric acid which assists in the smelting of aluminum. Each use requires a different grade of fluorspar, noted as metallurgical and acid grades, respectively. About 80% of fluorspar consumed in the United States is imported; Mexico supplies about 60% of the imports. Domestic production is concentrated in the Illinois-Kentucky district, which straddles the Ohio River northeast of Paducah, Kentucky. About 85% of domestic production is from nine mines operated by three companies in this district. Remaining production is from six mines in Arizona, Montana, Nevada, Texas and Utah. Metallic

grade fluorspar is used in all types of steelmaking, but is of particular importance to the basic oxygen process. Briquettes fabricated from lower quality fluorspar are being used more often because of declining reserves of good quality natural fluorspar.

Expected contingency movements of stockpiled materials used by the iron and steel industry are expected to be moderate for a variety of reasons. The primary limiting factor is that large amounts of material are stored in the vicinity of steel production areas. Further, a large proportion of the stockpiles are at sites not served by water. Water shipments of ferroalloys are likely in a contingency because such movements do occur in peacetime. Table II-5 gives the origins from which water shipments could be expected, including locations where ores would be converted before shipment. Large stockpiles of materials at Clairton, Pennsylvania, Curtis Bay, Maryland, and Granite City/East St. Louis, Illinois, are all very close to major steelmaking facilities, which reduces greatly the probability of long-distance water movements.

Although it is not stockpiled by the government, iron ore is considered a strategic material because of a heavy reliance on imports (about one-third of total consumption during the last decade). Canada supplies about 56% of iron ore imports, while Venezuela provides 19%, and Brazil provides 13%. Imported ores are especially important to steel mills at Bethlehem and Fairless Hills, Pennsylvania, Sparrows Point, Maryland, Georgetown, South Carolina, Birmingham, and Gadsen, Alabama, Granite City, Illinois, Houston, Texas, Portland, Oregon, and those on the Great Lakes.

The Lake Superior District accounts for about 84% of national output. Minnesota produced 62% and Michigan provided 21% in 1976, principally from the Mesabi and Marquette Ranges respectively. About 95% of Lake Superior District output is shipped through six ports on Lake Superior and one on upper Lake Michigan. In 1976, ships carried about 42% of total United States iron ore consumption and 66% of United States iron ore production through the Soo Locks. Other states with significant iron ore production are California, Wyoming, Utah, Missouri, New York, and Texas. Very little of the production from these states is transported by water.[21]

Table II-5

Potential Origins of Stockpiled Iron and Steel Industry Materials Moving by Water

Location	Stockpiled Material	Inventory(1)
GSA Depot, Point Pleasant, WV	Chromite Ore	244,200 SDT
	Ferrochromium	23,306 ST
	Ferromanganese	3,588 ST
	Manganese Ore	9,637 SDT
	Zinc	21,278 ST
Union Carbide, Marietta, OH	Chromite Ore	6,554 SDT
	Silicomanganese	10,182 ST
GSA Leased Site, Clairton, PA	Ferrochromium	76,703 ST
	Fluorspar	35,543 SDT
	Manganese Ore	364,785 SDT
Union Carbide, Alloy, WV	Manganese Ore	154,363 SDT
Installation Support Activity, Granite Cite, IL	Zinc	24,818 ST
Aluminum Company of America, East St. Louis, IL	Fluorspar	47,821 SDT
Defense Depot, Memphis, TN	Fluorspar	83,676 SDT
Pine Bluff Arsenal, Arsenal, AR	Fluorspar	44,090 SDT
Tennessee Valley Authority, Muscle Shoals, AL	Manganese Ore	117,115 SDT
Redstone Arsenal, Huntsville, AL	Zinc	14,382 ST
Airco Alloys, Charleston, SC	Chromite Ore	31,035 SDT
GSA Depot, Curtis Bay, MD	Chromite Ore	147,664 SDT
	Ferrochromium	113,945 ST
	Ferrochromium-silicon	10,865 ST
	Ferromanganese	218,212 ST
	Fluorspar	28,861 SDT
	Manganese Ore	58,800 SDT
Wilmington Marine Terminal, Wilmington, DE	Fluorspar	119,195 SDT
Seneca Army Depot, Kendaia, NY	Chromite Ore	202,027 SDT
GSA Depot, Port Clinton, OH	Manganese Ore	195,312 SDT

Note: (1) ST = short tons; SDT = short dry tons.

Source: Federal Emergency Management Agency.

During a contingency situation, there is a likelihood that deep-draft ocean movements of iron ore will decrease, with an increase of lesser magnitude on the inland waterways. Most disrupted would be iron ore movements into the Baltimore/Eastern Pennsylvania area; for these plants, rail is the only viable substitute for ocean shipping. Alabama plants could potentially continue to receive iron ore by water, but with a change in origin and length of move. Canadian sources would likely remain viable, so key connecting channels on the Great Lakes will have to remain open: the St. Lawrence Seaway, the Welland Canal, the Detroit River/Lake St. Clair/St. Clair River channels, the Soo Locks/St. Mary's River, and the Straits of Mackinac.

DREDGING REQUIREMENTS

Pursuant to Public Law 95-269, the Chief of Engineers, United States Army, has conducted studies to determine the requirements for a minimum fleet of federally-owned dredges. A report on hopper dredges was completed in September, 1978, and a separate report on other types is currently under review. National defense and emergency dredging requirements were the basis for recommending a minimum fleet of hopper dredges. The three types of national defense dredging requirements considered were:

1. Overseas ports, including those in Hawaii and Puerto Rico, where local dredging capabilities cannot meet United States military deployment and operational requirements.

2. United States ports used for military unit deployments and resupply cargo movements.

3. Inland waterways on which strategic materials are transported. Included were the Great Lakes and the Mississippi, Ohio and Missouri Rivers.

A fleet of twenty dredges of the types and locations shown in Table II-6 has been estimated to meet the national defense requirement. One unique, large class hopper dredge, especially designed to meet the rapid shoaling requirements of delta regions such as the Lower Mississippi River Passes, would be needed.

Table II-6
Federally-Owned Minimum Dredge Fleet Requirements

Type	East Coast	West Coast	Gulf Coast	Great Lakes	River System	Other Purposes	Total
Large Hopper	-	-	1	-	-	-	1
Medium Hopper	1	1	1	-	-	-	3
Small Hopper	1	1	-	2	-	-	4
Large Cutterhead	1	1	-	-	-	-	2
Medium Cutterhead	-	-	1	-	1	-	2
Dustpan	-	-	-	-	3	-	3
Side Caster	2	-	-	-	-	-	2
Special Purpose	2	-	-	-	-	-	2
Research and Development	-	-	-	-	-	1	1
Regional Totals	7	3	3	2	4	1	20

Source: U.S. Army Corps of Engineers.

A review of the hopper dredge study provides the following conclusions. The report notes that there were several assumptions made which would tend to underestimate the required fleet size. Such assumptions include no allowance for movements within a geographical region, sequential (as opposed to simultaneous) defense and other types of emergencies, no allowance for possible damage to dredges, and nonsimultaneous overseas and United States requirements. The Corps must assess the implications of these assumptions.

Preceding sections of this report noted other types of national defense requirements not addressed by the hopper dredge study. United States Navy requirements are missing, although it appears that most have been addressed as they are in commercial harbors. Another requirement is the maintenance of the shallow-draft terminals where military fuel is handled. This alone could add one more dredge to both the East and Gulf Coast requirements.

Finally, inland waterways with strategic material movements not specifically addressed in the hopper dredge study are the Columbia River, the McClellan-Kerr Arkansas River Navigation System, the Illinois Waterway, the Black Warrior-Tombigbee System, the Tennessee River, the Kanawha River, the Monongahela River, and the Gulf Intracoastal Waterway. These additional national defense requirements may exceed the capabilities of the recommended minimum dredge fleet.

WINTER NAVIGATION

Because military contingencies can occur at any time, an assessment of the national defense value of winter navigation on selected river segments is in order. Waterways which are subject to seasonal navigation closure are the Upper Mississippi River, the Missouri River, the New York State Canal System, the Great Lakes/St. Lawrence Seaway system, and ports on the Bering and Arctic Sea coasts of Alaska. Of these segments, only the New York State Canal system and the Great Lakes/St. Lawrence Seaway system are likely to have national defense requirements that could justify winter navigation.

The New York State Canal system handles fuel movements to Air Force installations in New York and Vermont. However, alternatives are available for moving fuel to these installations if the waterways are closed, so winter navigation would not necessarily be required.

On the other hand, the Great Lakes and St. Lawrence Seaway can be considered to possess strategic importance if winter navigation could be extended during a military contingency. Year-round navigation in the Great Lakes and eleven-month navigation in the St. Lawrence Seaway would require a major investment in icebreakers, lock modifications, vessel traffic control systems, and other items. As noted in the Element K1 report, the investment cost of such a proposal would be over $1 billion, with annual costs of over $100,000. At a minimum, five new WTBG-class United States Coast Guard icebreakers would be required, at a cost of $32 million.

An assessment of the national defense value of providing at least some additional winter navigation capability on the Great Lakes and St. Lawrence Seaway is beyond the scope of this study. Should the Department of Defense conduct a future study of total waterways system contingency requirements, it is recommended that the assessment include winter navigation on the Great Lakes/St. Lawrence Seaway system.

III - NONDEFENSE EMERGENCY CONSIDERATIONS

INTRODUCTION

Federal emergency planning encompasses a variety of crisis situations which can affect the waterways system. Plans have been developed to cover natural disasters, labor disruptions, other types of disasters (such as explosions or fires), and national emergencies. Each of the federal agencies assigned responsibilities for emergency planning is required to develop, implement, test and update those plans. At various times, some of the emergency plans have been used, and this section reviews selected situations, including the Arab Oil Embargo of 1973.

The common philosophy of all nondefense emergency planning is to develop an organizational structure capable of responding quickly and flexibly to whatever situation may develop. The United States Army Corps of Engineers and United States Coast Guard have incorporated such planning as part of their normal district functions. The principal requirement is to ensure that those plans are up to date and that they anticipate likely emergency situations. Likewise, those agencies should make sure that adequate materials and other resources are available to implement emergency plans. Appendix C outlines the impact on Columbia River navigation due to the Mount Saint Helens eruption of May 18, 1980.

The principal role for the waterways system during any emergency is likely to be the movement of fuels, bulk materials used in the production of critical materials, and water purification materials, as directed by emergency control authorities.

WATERWAYS CONTROL AND OPERATIONS RESPONSIBILITIES

(a) Federal Disaster Assistance

Federal disaster assistance to local agencies is authorized by the Disaster Relief Act of 1974 (Public Law

93-288). A major disaster is defined under the act as any "hurricane, tornado, storm, flood, high water, wind-driven water, tidal wave, tsunami, earthquake, volcanic eruption, landslide, mudslide, snowstorm, drought, fire, explosion, or other catastrophe which, in the determination of the President causes damage of sufficient severity and magnitude to warrant major disaster assistance above and beyond emergency services by the Federal Government to supplement the efforts and available resources of states, local governments, and private relief organizations in alleviating the damage, loss, hardship or suffering caused by a disaster."

Responsibility for administering the Act has been delegated to the Federal Emergency Management Agency (FEMA). Program assistance is primarily grants and loans which can be authorized only upon Presidential declaration of a major disaster or emergency. When necessary, FEMA can order federal agencies to provide direct assistance in major disasters or emergencies with or without reimbursement.[22]

In addition to providing damage assessment, technical advice, engineering services, and emergency work as directed by FEMA, the United States Army Corps of Engineers has been assigned additional natural disaster responsibilities for floods and coastal storms under Public Law 84-99, as amended by Section 206 of the Flood Control Act of 1962. This authority has been delegated to the Corps' division and district offices and can be exercised without a Presidential declaration of emergency.

The Corps is authorized to:

1. Preserve and operate federally-owned and maintained flood control works and other facilities operated by the Corps.

2. Furnish technical assistance to state and local authorities regarding maintenance of the integrity of flood control works, and federally authorized shore and hurricane protection projects under their jurisdiction.

3. Furnish direct assistance, either by supplying materials or equipment, or by undertaking federal flood fighting and reserve operations, as required.

4. Conduct special investigations of flood or coastal storm potential, investigate or make reconnaissance of flood or storm damage, and conduct postdisaster reporting.

These responsibilities include advance planning and program items within the Corps' annual budget, to cover expected activities under this Act.[23]

(b) Federal Emergency Transportation Programs

Legislation creating the United States Department of Transportation (Public Law 89-670) directs the Secretary to "exercise leadership under the direction of the President in transportation matters, including those affecting the national defense and those involving national or regional emergencies..." Accordingly, the Secretary of Transportation is responsible for the development and coordination of overall policies, plans, and procedures for provision of centralized control of all modes of civil transportation in an emergency. The Office of Emergency Transportation is the peacetime staff element for ensuring the accomplishment of this mission.

Nondefense emergencies include all adverse regional or national situations resulting from natural disasters, disruptive work stoppages in the transportation industry, or other crises involving the general welfare. Control authority can be exercised only upon declaration of a national or regional emergency by the President or the Congress, or by special legislative or Presidential action. Upon declaration of an emergency, the Secretary of Transportation must make a determination as to the impact on the nation's transportation system and decide upon an appropriate course of action. Options available include actions by staff elements of DOT, by operating elements of DOT, and by other federal agencies, as well as civil transportation allocation actions.[17]

Emergency legislation permitting the President and/or federal agencies to exercise priorities and allocations actions can be expected in event of a national or regional

emergency. Another method by which emergency control can be exercised is through the Defense Production Act of 1950 (Public Law 81-774, as amended) if circumstances threaten to disrupt the production or transportation of materials vital to the national defense. During the recent winters when icing stopped navigation on the Ohio River, the President considered invoking the act so that industrial production and shipments could be controlled.[24]

The Department of Transportation Crisis Action Plan for any stoppage, strike, or other disruption of the transportation system envisions the Secretary of Transportation advising FEMA to request additional authority to manage the transportation system from the President, through a new Executive Order.[25] Such action was contemplated during the 1979 Teamsters' strike against the trucking industry.[24]

(c) Types of Response

Four types of nondefense emergency situations lead to different sets of agency actions which can affect the waterways system. Each situation is discussed separately.

1. Extreme Weather Conditions. Many storms, floods, and other weather conditions cause damage which can be repaired without disaster assistance under Public Law 93-288. The major situation affecting waterways is flood control activities conducted by the Corps of Engineers. An example of the actions which can be ordered by the Corps during floods is provided in the emergency plans of the New Orleans District.[23] As the Mississippi River rises the following sequence of activities would be followed.

(a) The United States Coast Guard would operate the vessel traffic control lights at Governor Nicholls Street Wharf in New Orleans, at Gretna, and Westwego.

(b) Reduced vessel speeds would be ordered along the levee system below Baton Rouge to prevent wave wash damage.

(c) The Bonnet Carre Spillway above New Orleans would be activated to divert floodwaters into Lake Ponchartrain.

(d) The Old River Control Structures would be operated to divert water into the Atchafalaya Basin. Berwick Lock (on Bayou Teche at Atchafalaya River), the East and West Calumet Floodgates (on Bayou Teche at Wax Lake Outlet), Bayou Boeuf Lock (GIWW at Morgan City), and the Charenton Floodway (Bayou Teche above Franklin, Louisiana) would be closed to contain floodwaters in the Atchafalaya Basin.

(e) Operate the Morganza Floodway to divert additional floodwaters into the Atchafalaya Basin.

(f) Close Bayou Sorrell Lock on the Port Allen-Morgan City Alternate Route in the east levee of the Atchafalaya Basin when navigation becomes hazardous.

Flood control activities on all waterways are directed by the Corps of Engineers, and actions similar to those noted occur in other districts. Closure of floodgates will stop navigation on channels passing through floodwalls, and the Corps can recommend to the Coast Guard complete cessation of navigation on high water segments. After floodwaters subside, the Corps is responsible for repairing damages to any structures it maintains. Repairs to private levees may be made under authority of Public Law 84-99. If directed by FEMA, the Corps will assist other agencies in repair operations.

In coastal areas, the Corps also has emergency plans for hurricanes, with emphasis on preventing storm-related flood damage. For example, New Orleans District hurricane plans call for the operation of locks and control structures until wind conditions make continued operation hazardous, at which time the structures will be closed unless otherwise ordered by the Section Chief.[26]

The most common damage to waterways from storms and hurricanes is silting of channels, which can take some time to correct. Removal of sunken vessels or other hazards to navigation will be conducted by the Corps, when necessary. Hurricanes Frederic in 1979 and Allen in 1980 caused extensive shoaling and damage in the Gulf Coast area. Emergency dredging activities were initiated by available federal dredging equipment immediately after passage of the storms, and, in the case of Allen, efforts were made to quickly supplement federal capabilities by contracting for private dredging equipment assistance where warranted.

The Coast Guard has statutory responsibility to save lives, protect property, and assist other government agencies. Coast Guard assistance during natural disasters is primarily assistance to local agencies and evacuation of personnel with helicopters, aircraft, or ships.

All of the storm emergency activities of the Corps of Engineers and the Coast Guard encompass protection of personnel and property, and assistance to local authorities as appropriate. No specific requirements for the waterways system exist, although the Corps must maintain assets to repair storm-related damages. Advance planning for extreme weather conditions consists of establishing points of contact, communications plans, agreements between agencies regarding responsibilities, procedures for obtaining and stockpiling resources, organizational structure, and evacuation procedures. The transportation capability of the waterways system will be used as necessary, but no specific requirements are spelled out in advance.

Low water levels resulting from prolonged dry spells may necessitate emergency dredging actions by the Corps to permit the continuation of navigation. During December 1980 and January 1981, river stages reached record low levels on the Lower Mississippi, forcing the temporary closure to navigation of certain sections until

emergency dredging actions restored sufficient channel depth to permit the resumption of navigation.

Private industry provides about 75 to 85% of the non-hopper maintenance dredging performed on inland waterways and in coastal areas. During emergencies, this capability has been used in the past by the Corps, and it is likely that this additional capability would be available to at least some extent to help overcome any shortfalls experienced by the federally-owned dredge fleet. Private dredges operated under government contract in South Vietnam during the Vietnam Conflict, and have also been used for channel restoration after natural disasters, as has been noted for Hurricane Allen, the Mount Saint Helens eruption, and the prolonged low water on the Lower Mississippi.

2. Labor or Other Disruptions. The Department of Transportation's Crisis Action Plan [25] establishes procedures to be followed in a significant crisis caused by stoppage, strike, or other disruption (except defense emergency) affecting the transportation system. The plan envisions three levels of crisis situation actions.

Level One. Civil transportation services are operating at or near normal conditions, and all elements of DOT maintain their normal state of preparedness and organizational relationships. Data are collected and the situation monitored to be alert to potential disruptions in any mode.

Level Two. In situations requiring immediate Departmental response, an appropriate official will be appointed as the DOT Crisis Coordinator for the affected mode. Inland waterways, ports, and shipping will be coordinated through the United States Coast Guard, with assistance from the St. Lawrence Seaway Corporation if applicable. This level of action will be undertaken when interruptions to normal civil transportation have occurred or threaten to occur, causing a serious adverse effect upon the economy, the general welfare, or national security.

The Crisis Coordinator is the focal point for data collection and response actions, and also serves as the principal contact point for FEMA and other agencies. His primary role is to keep the Secretary currently advised on all facts related to the situation, and to carry out continuous planning for actions to be taken.

Level Three. Whenever the situation represents a major threat to the economy, general welfare, or national defense, the Secretary will request special federal legislative or executive authority to exercise a system of transportation priorities and allocations to move essential traffic. The Secretary will request this authority from FEMA, which will either direct the Secretary to assume such authority pursuant to Executive Order 10480, as amended, or will initiate action to obtain new authority from the President. When approved, the Secretary can delegate this authority to the heads of relevant transportation agencies (e.g., the Interstate Commerce Commission) or the DOT Crisis Coordinator. The entire plan envisions a progression of actions tailored to the situation at hand.

Discussions with the Chief of the Office of Emergency Transportation reveal that the concept of emergency planning is to establish responsibilities in advance, with those agencies given wide latitude to select the type of response appropriate to the situation.[25] Thus, DOT has no emergency plan which specifies waterways transportation requirements in advance.

Icing of the waterways system has disrupted transportation during exceedingly cold winters. The Ohio and Illinois Rivers have been most affected when icing has been severe, although navigation has proceeded year-round on those rivers. On the Ohio River, several programs have been adopted to cope with icing. The Corps of Engineers has an informal lock priority system which gives fuel movements the highest priority. Two industry-government committees have been formed on the Mississippi and Ohio Rivers to monitor weather, river and ice conditions, and to prevent ice blockages from developing. Vessels used to break up ice will be volunteered by various companies who will absorb the operational and labor costs.[27]

3. Declared Major Disasters or Emergencies. Whenever a disaster causes damages beyond the capabilities of state and local government agencies, state disaster officials in the affected area can request a joint survey of the damages with the Regional Director of the Federal Emergency Management Agency. A determination of eligibility under Public Law 93-288 will be made by FEMA, along with an estimate of the types of federal assistance required. The Governor can then request the President to

declare a major disaster or emergency. An emergency requires only specialized federal assistance to cope with the situation, whereas a major disaster brings into play all programs available under Public Law 93-288.

Upon declaration by the President of a major disaster or emergency, FEMA will appoint a Federal Coordinating Officer who will immediately begin appraising the types of relief most urgently needed. The Coordinating Officer brings together federal, state, local, and (with their consent) private relief efforts to ensure maximum effectiveness.

A major role of the Corps of Engineers is to conduct damage surveys and investigations for the Coordinator. The primary form of federal assistance is in the form of grants and loans to fund local efforts, but if necessary, FEMA can request direct assistance from federal agencies. Corps assistance to FEMA includes technical advice to local agencies actually performing disaster relief work, and direct accomplishment of emergency work on public or private nonprofit facilities.

As is typical with federal emergency planning, the plans of FEMA and the Corps of Engineers set up organizations, responsibilities, lines of communication, and programs which are to be employed when a major disaster or emergency is declared. Also included are provisions for stockpiling material, conducting tests, and updating of plans. The philosophy is to provide an organizational structure which can be quickly implemented, with maximum flexibility of response.

A recent and dramatic example of Corps response in a major disaster situation is illustrated by actions subsequent to the May 18, 1980 volcanic eruption of Mount Saint Helens in southwestern Washington state. Debris and mud flows from the force of this tremendous eruption filled the nearby Toutle and Cowlitz rivers, and formed a mound in the Columbia River navigation channel which blocked deep draft traffic between Portland, Oregon, and the Pacific. The Corps immediately summoned all its West Coast hopper dredges for emergency channel restoration activities, and efforts were initiated to contract for private industry dredging assistance. Limited deep-draft traffic resumed after several days, but full channel restoration was a four-month long continuous emergency

dredging project. For a more detailed discussion of the navigation impacts of the Mount Saint Helens eruption, see Appendix C.

The Mount Saint Helens emergency is also illustrative of modifications which might occur to existing environmental regulations when the magnitude of the emergency situation warrants such actions. The Portland District of the United States Army Corps of Engineers completed a draft Environmental Impact Statement in preliminary form on July 25, 1980, outlining the possible impacts of alternative recovery operations as well as those underway. The final draft EIS was submitted to the Environmental Protection Agency September 19, 1980, almost four months after the initiation of emergency dredging to restore the navigation channel. Many procedural steps were abbreviated out of necessity in preparing the initial draft and, due to time constraints, a detailed review of each topic discussed was not possible by the date of submission. By implication, therefore, it would appear that certain environmental regulations may be interpreted with less rigidity in some situations, such as a critical navigation emergency.

4. National Emergencies. The most extensive emergency situation anticipated is a national emergency, which would be a crisis requiring extraordinary measures by the United States. Situations generally envisioned include severe and widespread damage from a nuclear accident, or international conflict in one of three categories: international tension, limited war, or general war. A state of national emergency can be declared only by the President or the Congress, but the precipitating situation need not be limited to those mentioned previously.

PRIORITIES AND ALLOCATION PROCEDURES

For nondefense emergencies other than national emergencies, federal planning provides maximum flexibility of action for the local agency directing the response. At their discretion, available transportation assets can be employed by local agents to move whatever materiel and personnel are required at the scene, with reimbursement provided from federal funds. Relief and construction supplies are the most likely candidates for water movements.

The general concept of federal national emergency planning is to assign certain agencies control and allocation authority for designated resources; however, these authorities cannot be exercised without a formal declaration of national emergency. Thus, the Department of Transportation has been assigned standby authority to allocate civil transportation resources, while the Department of the Interior has a similar assignment for water resource allocation. Other components of the federal government have been assigned to supervise specific industries under the general direction of the allocation agencies; for example, the Interstate Commerce Commission will direct motor carrier, railroad, and inland waterways operations.

Allocation agencies will periodically receive forecasts of capabilities from operating agencies. Other agencies will submit claims for resources, which the allocation agencies must then evaluate in light of capabilities and national priorities set by FEMA. For the waterways system, a division of authorities will exist between DOT and Interior regarding resource allocations, and among operating agencies which will separately oversee ports, inland waterways, ocean shipping, and Great Lakes shipping.

A transportation priority list has been prepared for national defense emergencies, and is shown in Table III-1; no significance is attached to the order of items given. In other nondefense emergencies, the same items may be expected to have transport priority. Of the items listed in Table III-1, the waterways will probably be primarily moving fuels and water purification materials in bulk.

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Table III-1

Transportation Priority List

1. Food or kindred products. canned, preserved or otherwise prepared, including fresh, frozen or chilled meats and poultry; fresh eggs and milk; fresh or frozen fruits and vegetables; fresh or frozen fish and shellfish; feeds for animals and fowls.

2. Hospital and sickroom supplies and equipment, including diagnostic devices and essential support utilities.

3. Pharmaceuticals, biologicals, surgical textiles and instruments.

4. Medical laboratory supplies and equipment.

5. Fuels required for the production of electric power and those used directly for heating residences and institutions essential for the public welfare.

6. Electrical power and communication systems repair materials and equipment required for the continued supply of essential electric power and communications.

7. Essential supplies and materials directly related to exploration, development and construction of energy producing systems.

8. Material moving on government or commercial bills of lading specifically certified as essential by Department of Defense, Department of Energy, or General Services Administration contract administrators.

9. All material moving on government bills of lading issued by transportation officers of the military services.

10. United States mail in accordance with emergency orders issued by the United States Postal Service.

11. Water and sewage processing and handling supplies and equipment, including chlorine, alum, lime, sulphate of iron, soda ash, and similar chemicals and equipment essential to the continuity of operation of water and sewage installations.

12. Items necessary to the continued smooth functioning of the financial system, i.e., movement of checks, currency and coins.

13. Federal government personnel on agency-designated essential travel orders and nonfederal government personnel on self-designated essential travel in support of items contained in this priority list.

SOURCE: United States Department of Transportation Crisis Action Plan.[25]

OIL EMBARGO OF 1973

Following the outbreak of the Middle East (Yom Kippur) War in October of 1973, certain Arab nations belonging to the Organization of Petroleum Exporting Countries (OPEC) instituted an embargo of oil exports to all countries supporting Israel. Countries which halted oil exports to the United States included all Persian Gulf nations, with the major exception of Iran. Most of the embargo's effects on the waterways system occurred during 1974.

To measure the effect, data on the movement of crude petroleum, residual fuel oil, distillate fuel oil, jet fuel and kerosene, and gasoline were drawn from Waterborne Commerce Statistics for the years 1969 through 1977. Appendix B contains petroleum product flows by water to/from nine domestic United States regions plus imports and exports for these years.

Table III-2 portrays total domestic demand for petroleum products for 1969-1976, as reported by the American Petroleum Institute. As noted by the Bureau of Mines, the drop in overall petroleum demand in 1974 was the first in 32 years. The largest absolute drop in demand was in distillate and residual fuel oils. A combination of product scarcity due to the Arab oil embargo, warm weather in early winter months, conservation efforts, higher petroleum product prices, and a general economic decline contributed to the decline in demand. Overall demand continued to decline in 1975, primarily due to the economic recession of 1974-75, although gasoline demand recovered to the 1973 level. By 1976, product demands had recovered to 1973 levels, with the exceptions of jet fuel and kerosene.

Petroleum and product imports, exports and domestic movements by water are shown in Tables III-3 through III-5. A notable statistic is that crude petroleum imports by water increased at a rate far above the apparent domestic demand for crude after 1970, and continued to increase even in 1974. This trend reflects a decline in United States crude oil production during the 1971-1976 period, prior to full production at Prudhoe Bay.

Interpretation of the effects of changing petroleum demands upon waterborne transportation movements during the 1969-1977 period is not precise, but a few broad trends are noticeable. First, the trends in overall waterborne movements of crude petroleum and residual fuel oil have not matched the trends in domestic demand for these materials during this period, due to a shift from domestic to foreign sources for these materials. Total waterborne flows of other refined products more closely followed United States demand patterns, with the split between import and domestic flows more stable, indicating less source substitution.

Second, it appears that domestic waterborne traffic decreased more rapidly in 1974 and 1975 than did demand for the lighter refined products. Crude and residual fuel oil movement trends were significantly different than demand trends. The implication is that pipeline movements of light refined products remained stable during the economic downturn, leaving the water mode more susceptible to the downturn in demand. Figures III-A through III-C highlight these trends.

Finally, the data on petroleum product exports show that such traffic is a very small component of total flow patterns. A comparison of the Waterborne Commerce Statistics and the American Petroleum Institute statistics on petroleum exports suggests that the data reported to the United States Army Corps of Engineers may not depict actual movements correctly. Given the relatively small volumes involved, a few unreported movements could create wide shifts in the statistics.

Overall, the Arab Oil Embargo seems to have caused a greater than average downturn in waterborne movements of light refined products, when compared to the change in domestic demand for the products. However, crude oil and residual fuel oil movements via water were much less affected by the embargo, with waterborne imports of crude oil actually increasing during the disruption.

Table III-2

Total Domestic Demand for Oil Products (Thousands of Barrels per Day)

	1969	1970	1971	1972	1973	1974	1975	1976	1977
Crude Petroleum (*)	12,232	12,613 (3.1)	12,871 (2.0)	13,846 (4.8)	14,296 (6.0)	14,025 (-1.9)	14,180 (1.1)	15,081 (6.4)	19,468 (9.1)
All Refined Products	14,137	14,697 (4.0)	15,213 (3.5)	16,367 (7.6)	17,308 (5.7)	16,652 (-3.8)	16,322 (-1.9)	17,461 (7.0)	18,431 (5.6)
Residual Fuel Oil	1,978	2,204 (11.4)	2,296 (4.2)	2,529 (10.1)	2,823 (11.6)	2,639 (-6.5)	2,461 (-6.7)	2,799 (13.7)	3,071 (9.7)
Distillate Fuel Oil	2,466	2,540 (3.0)	2,661 (4.8)	2,913 (9.5)	3,092 (6.1)	2,948 (-4.7)	2,851 (-3.3)	3,133 (9.9)	3,352 (7.0)
Gasoline	5,596	5,839 (4.3)	6,061 (3.8)	6,421 (5.9)	6,718 (4.6)	6,582 (-2.0)	6,713 (2.0)	7,014 (4.5)	7,214 (2.9)
Jet Fuel and Kerosene	1,266	1,230 (-2.8)	1,260 (2.4)	1,281 (1.7)	1,275 (-0.5)	1,169 (-8.3)	1,159 (-0.9)	1,157 (-0.2)	1,214 (4.9)

Notes: (*) Includes crude oil, condensates, natural gas condensates; net of production plus imports minus exports.

Year-to-year percentage change is shown in parentheses.

Source: Basic Petroleum Data Book, American Petroleum Institute.

Table III-3

Total Imports of Oil Products by Water
(Millions of Tons)

	1969	1970	1971	1972	1973	1974	1975	1976	1977
Crude Petroleum	94.3	93.6 (-0.8)	116.5 (24.6)	143.5 (23.1)	196.6 (37.0)	216.0 (9.9)	255.9 (18.5)	337.2 (31.8)	405.1 (20.1)
Residual Fuel Oil	76.6	88.0 (14.9)	80.1 (-8.9)	76.1 (-5.0)	86.5 (13.7)	80.4 (-7.1)	58.5 (-27.3)	65.9 (12.8)	66.2 ([illegible])
Distillate Fuel Oil	1.6	2.2 (37.4)	5.9 (163.0)	17.5 (202.9)	30.3 (73.6)	12.0 (-60.6)	5.7 (-52.5)	3.2 (-44.2)	[illegible] (144.4)
Gasoline	0.4	0.5 (14.0)	0.3 (-36.3)	0.5 (51.2)	2.8 (472.7)	5.2 (88.1)	3.4 (-35.8)	1.4 (-58.0)	[illegible] (146.0)
Jet Fuel and Kerosene	7.9	8.7 (9.8)	8.6 (-0.9)	8.9 (2.9)	10.3 (15.4)	8.1 (-21.5)	4.6 (-42.8)	3.0 (-34.3)	[illegible] ([illegible])

Note: Year-to-year percentage change is shown in parentheses.

Source: Waterborne Commerce Statistics (Appendix B).

Table III-4

Total Exports of Oil Products by Water
(Thousands of Tons)

	1969	1970	1971	1972	1973	1974	1975	1976	1977
Crude Petroleum	255.1	611.9 (139.9)	311.7 (-49.1)	417.8 (34.0)	420.1 (0.5)	129.5 (-69.2)	0.0 (100.0)	194.9 (N/A)	1,964.4 (907.9)
Residual Fuel Oil	2,702.0	3,336.4 (23.5)	2,373.3 (-28.9)	2,022.3 (-14.8)	1,881.7 (-7.0)	790.9 (-58.0)	1,402.0 (77.3)	612.7 (-56.3)	302.7 (-50.6)
Distillate Fuel Oil	325.0	300.9 (-63.5)	230.7 (-23.3)	120.2 (-47.9)	604.7 (403.2)	102.9 (-83.0)	101.7 (-1.1)	22.5 (-77.9)	12.3 (-45.3)
Gasoline	208.4	114.4 (-45.1)	210.9 (83.9)	70.4 (-66.6)	338.6 (381.1)	74.3 (-77.7)	16.0 (-78.8)	22.6 (41.4)	90.9 (302.9)
Jet Fuel and Kerosene	48.4	20.5 (-57.7)	24.1 (17.6)	32.6 (35.4)	101.8 (212.4)	78.1 (-23.3)	39.8 (-49.1)	17.5 (-56.0)	7.8 (-55.5)

Note: Year-to-year percentage change is shown in parentheses.

Source: Waterborne Commerce Statistics (Appendix B).

Table III-5

Total Domestic Flows of Oil Products by Water
(Millions of Tons)

	1969	1970	1971	1972	1973	1974	1975	1976	1977
Crude Petroleum	109.7	116.3 (6.0)	114.8 (-1.3)	103.7 (-9.7)	91.0 (-12.2)	83.6 (-8.1)	77.9 (-6.8)	75.4 (-3.3)	81.6 (8.3)
Residual Fuel Oil	64.8	79.3 (22.4)	89.5 (12.9)	103.0 (15.1)	110.3 (7.1)	112.4 (1.9)	112.2 (-0.2)	128.7 (14.7)	136.1 (5.7)
Distillate Fuel Oil	77.9	76.3 (-2.1)	78.3 ([illegible])	85.5 (9.2)	84.7 (-0.9)	83.8 (-1.1)	87.6 (4.5)	89.6 (2.3)	89.8 (0.2)
Gasoline	85.4	88.7 (3.9)	91.5 (5.4)	93.6 (0.1)	94.1 (0.5)	90.2 (-4.1)	92.3 (2.3)	92.8 (0.6)	94.9 (2.2)
Jet Fuel and Kerosene	21.9	20.[illegible] (-7.8)	19.6 (-2.5)	19.3 (-1.9)	18.1 (-5.8)	15.2 (-16.2)	14.4 (-5.4)	16.1 (12.0)	18.1 (12.4)

Note: Year-to-year percentage change is shown in parentheses.

Source: Waterborne Commerce Statistics (Appendix B).

FIGURE III-A

TOTAL DOMESTIC DEMAND FOR OIL PRODUCTS

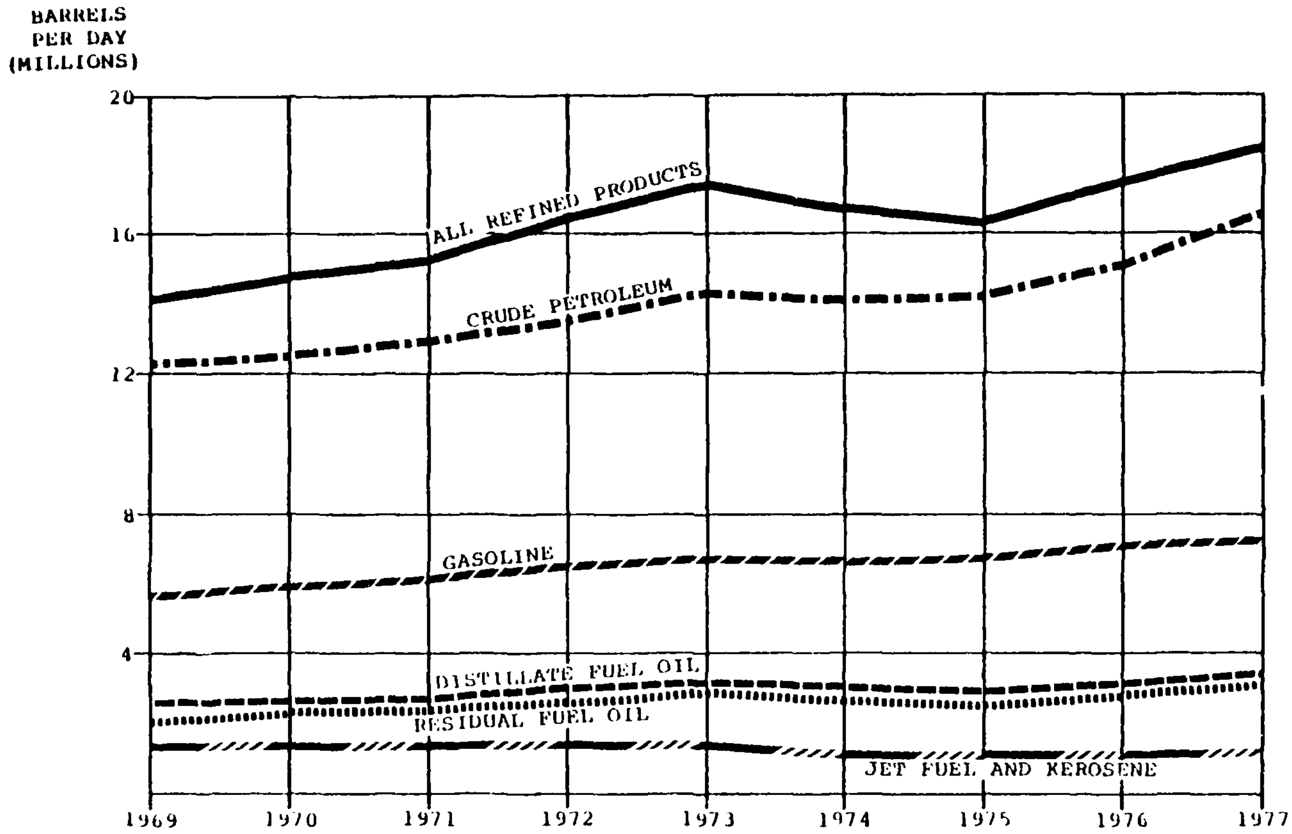


FIGURE III-B

DOMESTIC WATERBORNE FLOWS OF OIL PRODUCTS

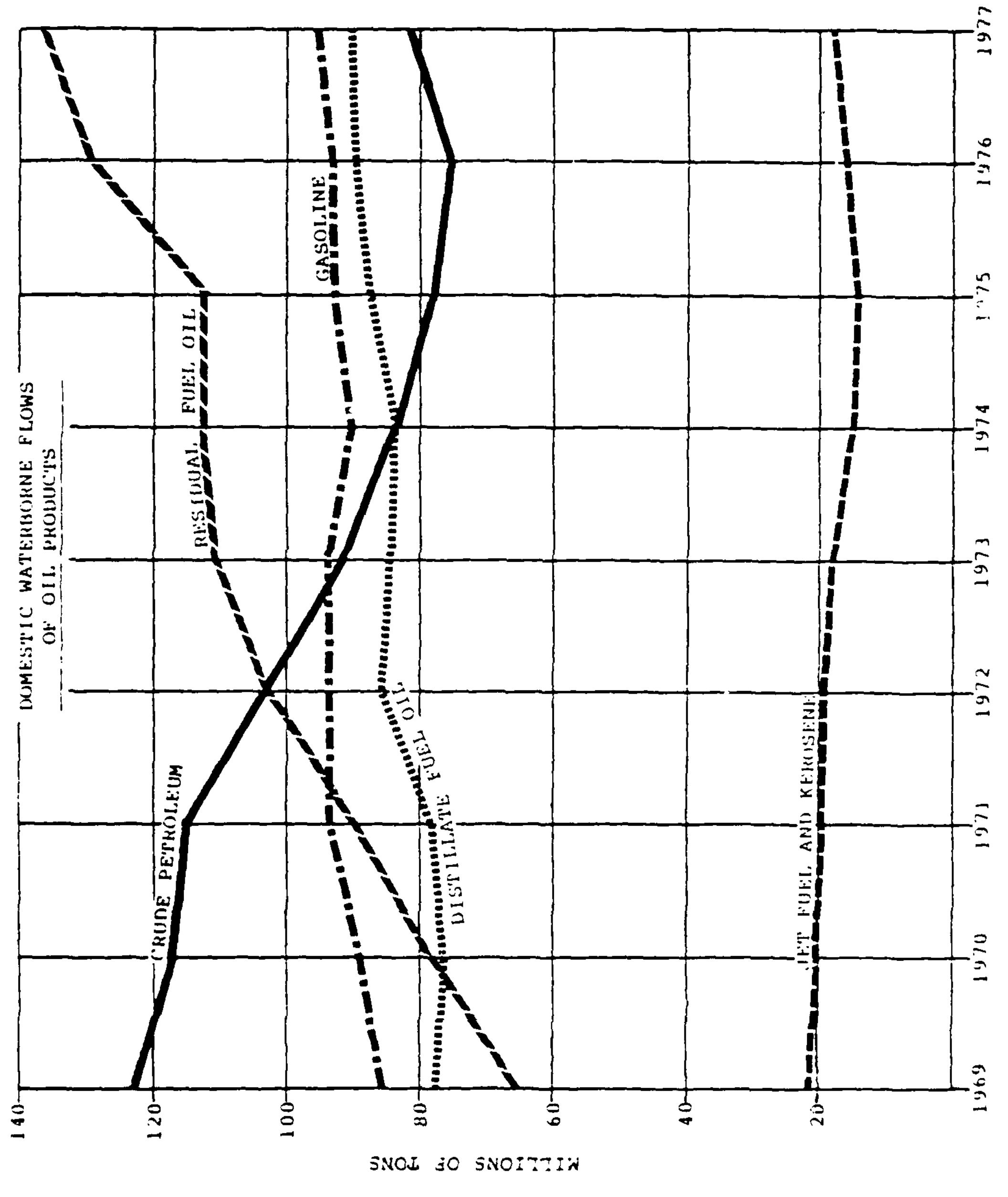
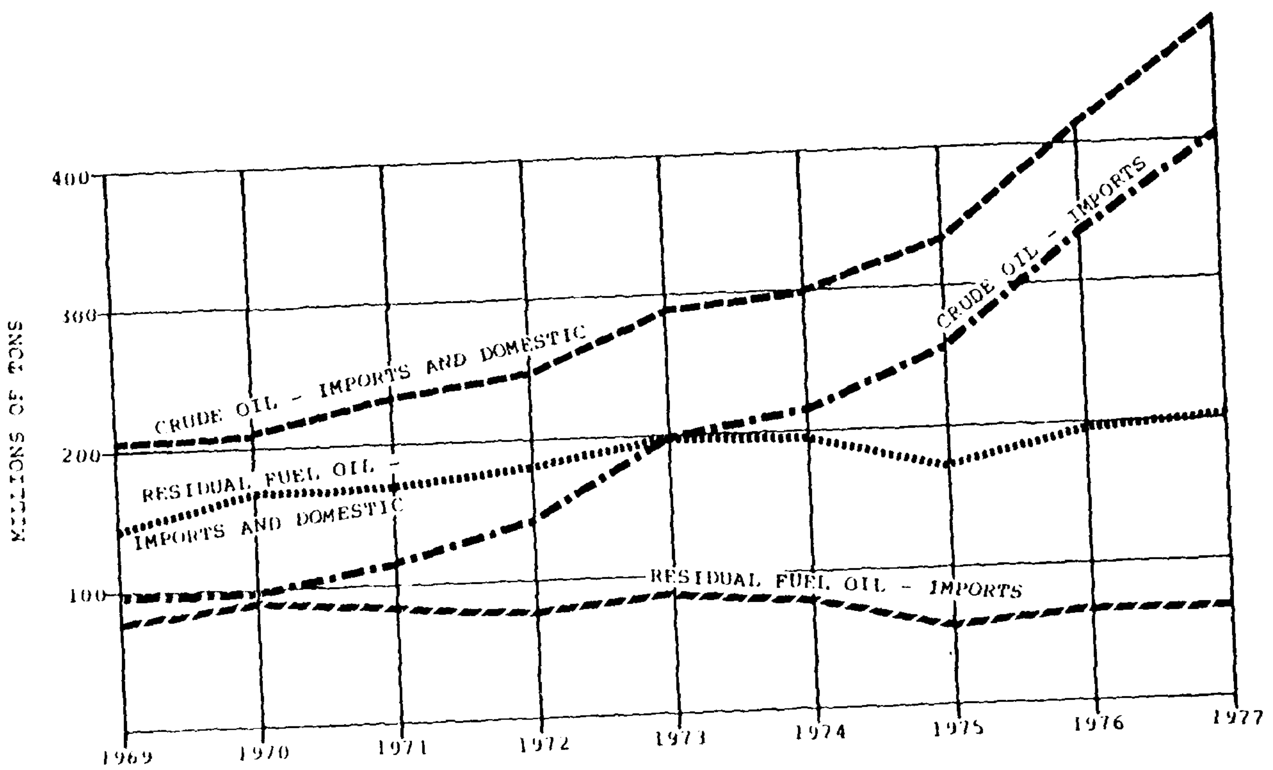


FIGURE III-C

WATERBORNE FLOWS FOR CRUDE AND RESIDUAL FUEL OIL



IV - SAFETY ASPECTS OF THE WATERWAYS SYSTEM

INTRODUCTION

Waterways safety, as defined for this report, is restricted to the topics of accidents which involve a vessel - a "vessel casualty" as defined by the United States Coast Guard; the damages and personnel injuries that result from vessel casualties, including the associated level of risk; and strategies for reducing the incidence of and damages from vessel casualties. Specifically excluded are personnel injuries and deaths which are not caused by a vessel casualty, and structural failures of dams and bridges, when a vessel is not involved.

Waterway accidents examined in this section are those vessel casualties reported to the United States Coast Guard whenever the casualty involves the vessel itself or its cargo. Accident types included are:

1. Collisions.
2. Rammings (collisions with fixed structures or stationary vessels).
3. Fires and/or explosions.
4. Groundings.
5. Founderings, capsizings, floodings, and swampings.
6. Weather damages.
7. Cargo damage, with no damage to the vessel.
8. Material failures of a vessel's structure or handling equipment.
9. Barge breakaways.
10. Others (enemy action, earthquakes, etc.).

Accidents within the scope of this report are further limited to locations within the coastal and inland waters

of the United States, including Alaska, Hawaii, and Puerto Rico.

A magnetic tape copy of the vessel casualty report files covering the fiscal years 1977 and 1978 was obtained from the Office of Information and Analysis, United States Coast Guard Headquarters, and used to produce certain summaries noted within this report.

The objective of this research was to determine those issues related to waterways system safety which should be addressed within national waterways system strategies. More specifically, likely policy actions include funding levels for existing United States Coast Guard and United States Army Corps of Engineers programs, new programs which improve waterways system safety, and federal legislation and regulatory actions. Actions which are appropriate will involve either waterways system configuration, maintenance, or traffic control procedures.

TYPES OF VESSEL CASUALTIES

(a) General Observations

A summation of the vessel casualties and estimated losses reported to the United States Coast Guard in Fiscal Year 1978 is presented in Table IV-1.[28] It should be noted that all towboats, barges, or assisting tugs, damaged in a casualty, are counted individually. The two primary causes of a casualty were personnel fault (28%) and fault on the part of the other vessel (41%).

Exhibit IV-1, reproduced from the 1979 Coast Guard Marine Safety Review, graphs the relationship between five casualty types and the five most frequent causes of each, for the years 1971 through 1977. Between 1972 and 1974, there was a notable increase in the number of licensed persons in charge, due to new licensing requirements. The trend for combined licensed and unlicensed personnel faults indicates human failure is increasing as a primary cause in groundings and rammings, but not collisions.

The most common vessel types involved in accidents during 1978, ranked by frequency were: tugs and towboats (25.4%); fishing vessels (16.6%); cargo barges (16.4%); cargo vessels (12.2%); tank barges (11.2%); tankships (6.7%); and passenger/ferry vessels (4.3%). When the 1978 casualty records were screened by computer to select only the vessel which initiates a casualty (the primary vessel), the ranking changed to: tugs and towboats (29.0%); fishing vessels (26.5%); cargo vessels (17.1%); tankships (9.5%); passenger/ferry vessels (6.8%); cargo barges (3.8%); and tank barges (1.6%). This change in rankings depicts the types of vessels which tend to initiate casualties.

Locations of vessel casualties in domestic waters are also shown in Table IV-1. Note that certain types of accidents tend to be associated with specific areas. Vessel collisions are frequent in the Inland Gulf area, which includes the waters of the Gulf Coast where Inland Rules of the Road apply. Rammings and founderings/capsizings/floodings are noticeably more frequent on the inland waterways where the Western River Rules of the Road apply, principally on the Mississippi River and its tributaries. Groundings are frequent in the Inland Atlantic area, while material failures stand out in the Inland Pacific area.

A more detailed breakdown of the combined 1977 and 1978 casualty locations by waterways segment (with correction of assumed coding errors) is provided as Exhibit IV-2, for selected types of casualties. Also included as Exhibit IV-3 are graphs indicating the most frequent types of casualties in seven port areas, for calendar years 1971 to 1977. A more detailed analysis and discussion about accident locations is presented in following paragraphs of this section.

(b) Selection of Primary Casualties for NWS Analysis

Table IV-1 suggests certain relationships between types of accidents and their primary causes for all vessel casualties. When the 1977-1978 United States Coast Guard data were summarized for only the primary (initiating)

Table IV-1

Summary

Vessel Casualties by Casualty Nature
Fiscal Year 1978

	Collisions Crossing, Meeting and Overtaking	Collisions while Anchored, Docking or Undocking	Collisions with Piers, Bridges, Locks and Dams	Other Collisions	Grounding with Damage to Vessel	Grounding without Damage to Vessel	Explosions and/or Fires	Founderings, Capsizings and Floodings	Material Failures	Total Casualties
Number of Casualties	309	253	618	348	428	599	210	521	854	4,268
Number of Vessels Involved	894	688	1,244	587	700	908	229	651	951	7,118
Number of Inspected Vessels Involved	230	186	356	175	208	257	62	67	508	2,131
Number of Uninspected Vessels Involved	664	592	888	412	492	651	167	584	443	4,987
PRIMARY CAUSE										
Personnel Fault:										
Pilots	21	20	50	7	14	42	1	2	1	162
Licensed/Documented	140	318	169	119	172	195	6	41	15	1,202
Unlicensed/Undocumented	76	31	26	42	90	95	5	68	[illegible]	44[illegible]
Others	16	13	12	12	12	38	15	13	14	190
Storms	6	8	10	22	15	32	-	94	102	360
Unusual Currents	-	-	7	3	-	3	-	8	1	24
Sheer, Suction, Bank Cushion	9	1	3	1	3	3	-	-	-	20
Failure of Equipment	19	37	53	21	37	17	77	76	657	1,024
Unseaworthy	1	-	2	-	1	1	-	102	22	128
Depth of Water Less than Expected	-	2	-	5	10	129	-	-	-	166
Floating Debris, Submerged Objects	1	-	9	78	6	2	-	21	5	124
Fault of Other Vessel or Person	586	437	682	245	277	316	19	147	110	2,922
Other/Unknown	19	15	21	37	21	15	106	77	22	349
TYPE OF VESSEL										
Inspected										
Passenger and Ferry	24	19	28	[illegible]	26	13	14	10	115	309
Freight	36	44	111	40	39	73	21	9	205	611
Cargo Barge	3	1	7	3	3	1	-	-	2	20
Tankship	14	34	41	23	19	45	13	7	118	319
Tank Barge	142	78	163	64	114	123	11	19	50	799
Other	11	10	6	17	6	1	3	2	38	73
Uninspected										
Fishing	117	80	25	71	127	172	73	224	265	1,180
Tug/Towing	273	163	471	173	175	241	45	140	86	1,811
Foreign/Other	274	259	392	168	190	216	49	212	92	1,996
LOCATION(1)										
Inland Atlantic	34	52	105	65	87	171	28	89	87	716
Western Rivers	51	27	189	32	77	110	16	95	19	672
Inland Pacific	22	36	55	66	71	99	37	69	135	596
Inland Gulf	123	80	131	71	69	100	47	79	49	778
Great Lakes	5	5	68	14	25	38	7	7	86	260
ESTIMATED LOSSES ($ 000)										
Vessel	$16,211	$6,908	$15,295	$9,195						
Cargo	2,675	595	1,777	998						
Property	1,225	1,642	11,699	4,377						

Notes: (1) Domestic waterways only; excludes ocean areas.

Source: U.S. Coast Guard Marine Safety Statistical Review 1979. [28]

vessels, the information in Exhibit IV-4 was produced. One significant relationship is that personnel fault is the primary cause of collisions, rammings, and groundings. Equipment failure is a notable secondary cause for these same casualty types. In explosions and/or fires, equipment failure is the predominant cause. Founderings/capsizings/floodings are caused about equally by personnel fault, unseaworthiness, storms, and equipment failures. Material failures are overwhelmingly caused by equipment failure, although storms are also an important cause.

When equipment failures occur, analysis of the 1977-1978 records indicates the most common problems cited are wasted steel or welds, and failures of the deck equipment, electrical system, hydraulic system, and propulsion system. Unseaworthiness and improper maintenance are generally associated with failure or deterioration of the hull. All of these problems are related to vessel design, inspection and maintenance procedures.

When weather causes casualties, the most common factors cited are large swells, ice, gale force winds, an anchor which failed to hold, restricted visibility, separation of a tow or mooring line, and shifting cargo. For the miscellaneous group of causes, the most common factors are fires of undetermined origin, wake damage from other vessels, progressive flooding and vandalism.

Relations between causes and associated factors for vessel casualties other than collisions, rammings and groundings indicate problems in the areas of vessel design and maintenance, improper evaluation of weather conditions, or random events. A common casualty (occurring about 50 times annually) that encompasses all these factors is the capsizing of an uninspected fishing vessel in bad weather. None of the accident factors cited (with the exceptions of wake damage and restricted visibility) relate to waterways system configuration or maintenance, or to vessel control problems.

Therefore, we will treat the following types of casualties as secondary for the purposes of the National Waterways Study:

1. Fires and/or explosions.

2. Founderings, capsizings, sinkings and floodings.

3. Weather damages.

4. Material failures of vessel structure or equipment.

5. Miscellaneous (earthquakes, enemy action, etc.).

Of primary interest to NWS are those vessel casualties whose causes relate directly to waterways system design or maintenance or which stem from vessel control problems. These casualties will be referred to as vessel control accidents. Our analysis will use the following groupings of primary casualty types:

1. Collisions between vessels: two or more moving vessels in a meeting, crossing, or overtaking situation [USCG categories 01, 02 and 03].

2. Collisions while docking or undocking: two or more vessels [USCG category 05].

3. Collisions with floating or submerged objects: objects other than ground, ice, or navigation aids [USCG category 08].

4. Rammings: collisions with an anchored or moored vessel (if not docking/undocking); with a pier, bridge, lock or dam; or with a navigation aid [USCG categories 04, 09, and 11].

5. Other collisions: collisions with a vessel in fog; with a vessel not otherwise classified (including minor bumps between vessel and tug); with ice; or with an object other than a vessel (e.g., offshore rigs, seaplanes) [USCG categories 06, 07, 10 and 12].

6. Groundings with damage: over $1,500 damage to the vessel [USCG category 21].

7. Groundings without damage: under $1,500 damage to the vessel [USCG category 22].

ANALYSIS OF VESSEL CONTROL ACCIDENTS

(a) Causes of Vessel Control Accidents

Two recent studies by ORI, Inc. for the Coast Guard [29, 30] examined in detail records of collisions, rammings, and groundings for the fiscal years 1972 through 1976, with the objective of identifying consistent patterns of causal and situational factors. One study [29] encompassed tows on all Western Rivers and the Gulf Intracoastal Waterway, excepting the Mississippi River below Mile 125 because of dissimilarity in the traffic mix. The other study [30] reviewed accidents in harbor areas involving either a tug/barge or a ship of greater than 10,000 gross registered tons.

Both studies concluded that collisions between vessels most often occur because at least one (and usually both) of the persons-in-charge fails to perform an essential task, typically the failure to establish bridge-to-bridge radio communication or otherwise signalling intentions. Failure to establish communication, when late detection of the other vessel was not a factor, was cited in 21% of the inland and 39% of the harbor collisions.

Failure to maintain position and late detection of the other vessel were the other major causal factors cited in both studies. Failure to maintain position is typically related to a misjudgment of the effects of wind and/or current, or by an inability to control vessel response in shallow waters or narrow channels. Both studies cited a high percentage of failure to use available equipment. The inland waterways study indicated that 31% of the vessels in collisions had their radios off or inoperable, while in the harbor study, 25% of the vessels had their radar off although apparently in working order.

Rammings and groundings were found in both studies to be similar in their primary causes: failure to maintain position against the effects of current and/or wind, miscalculation of vessel response, or failure to identify the hazard. Less common was failure to properly establish vessel position. Both reports note that vessel response against currents and wind effects in shallow waters and in narrow channels is not easily predictable and is not well understood. Equipment failures caused vessel control accidents in fewer than 10% of the cases examined in both studies.

(b) Location of Vessel Control Accidents

Situational factors were also found to be very important in the ORI studies. The inland waterways study concluded that 86% of the vessel control accidents (collisions, rammings, and groundings) reported in fiscal years 1972 through 1976 occurred on just five waterways: the Upper Mississippi River, the Illinois Waterway, the Ohio River, the Lower Mississippi River above New Orleans, and the Gulf Intracoastal Waterway - West. These waterways accounted for about 75% of the total shallow-draft Gulf Coast and Mississippi River System ton-miles in 1977. Within these waterways, thirty-five 10-mile segments, comprising about 10% of the total navigable distance, accounted for 35% of all inland accidents involving a towboat or barge.

Even though the frequency of vessel control accidents tends to increase with higher levels of vessel traffic, there are situational factors which greatly increase the likelihood of a vessel control accident occurring. The inland segments where vessel control accidents most frequently occurred had these characteristics in common:

- One or more bridges.
- One or more locks.
- Bridges and locks.
- A bend or intersection with another channel.
- A very narrow available channel width.

Most of the high accident segments had more than one of these characteristics. For accidents at bridges and locks, 65% of the locations were also within one-half mile of a bend.

Eighty percent of the river accidents occurred on downriver passages, which reflects control problems when following the current. A tendency was noted for accidents at bridges to occur during high water periods. However, the data suggested that accidents increase during periods when the water level is changing. In particular, groundings do not notably increase during low water stages, but do increase during stage changes, and are most common near bends or intersections with other waterways.

Another significant relationship noted was that collisions between vessels on inland waters often occurred at bends, at intersections, or in narrow channels. This was especially the case on the Gulf Intracoastal Waterway - West, which accounted for 45% of all collisions sampled. There was some evidence that a low ratio of tow width to available channel width was a factor in accidents at bridges, locks, bends, and in narrow channels. Accident case studies indicate a large number of failures in tow lashing gear leading to breakups, and a notable number of collisions and rammings (especially on the GIWW - West) occurring after tows have grounded.

The ORI harbor area study identified far fewer situational factors. Collisions were only secondarily associated with bends (20% of situations where a determination could be made) and bridges (7%), while another 7% were judged to be in complex maneuvering situations. However, 34% of the collisions occurred during an obscuring condition of the environment (fog, rain, snow, blinding lights, heavy seas, etc.). For groundings, 26% occurred when the vessel was negotiating a sharp bend (more than 20°), 7% involved a complex situation, and another 7% were related to shoaling. Obscuring conditions of the environment contributed to only 15% of the groundings.

The distribution of rammings was 36% with moored vessels, 28% with bridges, and 30% with other fixed objects (usually a dock). Over half the bridge rammings were at movable bridges, and in those cases the bridge typically failed to open in time. The number of bridge rammings is notable because of the relatively small number of movable bridges in harbor areas. Sharp turns were found in 27% of the rammings, while another 12% involved complex situations. Taking all the accidents studied as a group, situational factors are only secondary in harbor area accidents, but bridges, bends, and complex navigation conditions are still important.

RISKS ASSOCIATED WITH ACCIDENTS

An indication of the magnitude of damages caused by vessel casualties is shown in Table IV-2, which is from published Coast Guard statistics. The ORI study of vessel control accidents on inland waters [29] compared Coast Guard estimates of losses against actual insurance claim settlements for selected casualties, and found that, in the aggregate, the estimates are of the correct order of magnitude, although individual casualties showed significant variation.

Table IV-2 indicates that groundings, founderings, explosions and/or fires, collisions, and rammings (in that order) cause the greatest total monetary losses. In general, vessels themselves receive the most damage. The ten-year trend in overall estimated losses is shown in Figure IV-A. The total estimated annual losses of about $200 million represent a significant cost borne by vessel owners.

Table IV-2

Estimated Losses from Vessel Casualties

Fiscal Year 1978
($ Thousands, Current)

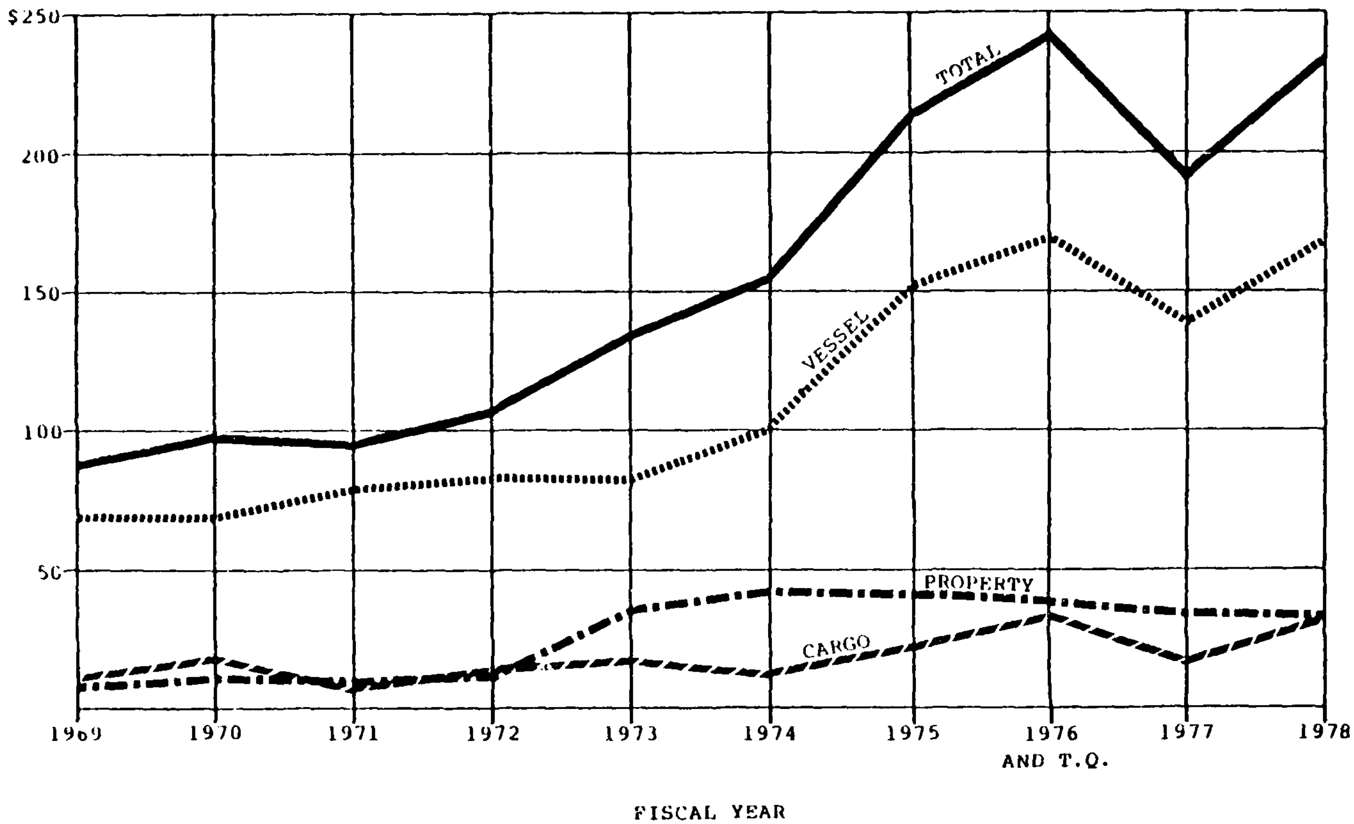
Type of Casualty	Vessel Losses	Cargo Losses	Property Losses	Vessels Totally Lost
Collisions -				
Meeting, Crossing, Overtaking	$ 16,311	$ 2,678	$ 1,225	15
While Anchored, Docking or Undocking	6,908	595	1,642	6
Other	9,195	998	4,377	5
Rammings -				
Piers, Bridges, Locks or Dams	15,295	1,777	11,699	8
Explosions and/or Fires -				
Cargo	2,716	80	9,999	2
Vessel's Fuel	6,776	35	7	1
Pressure Vessels, Boilers	233	10	10	-
Others	17,575	2,967	671	25
Groundings -				
With Vessel Damage	41,305	4,142	665	32
Without Vessel Damage	776	10	40	1
Founderings, Capsizings, Floodings	32,477	2,140	1,275	107
Heavy Weather Damage	38	35	-	-
Cargo Damage	23	655	40	-
Material Failures -				
Structure and Equipment	6,682	14,323	475	3
Machinery and Engineering Equipment	10,066	180	649	1
Total - All Types	$168,975	$31,090	$33,349	220

Note: Total includes other casualty types not shown.

Source: U.S. Coast Guard Marine Safety Statistical Review - 1979.

FIGURE IV-A

ESTIMATED LOSSES FROM VESSEL CASUALTIES



Several types of waterways accidents which have the potential for serious damages have been identified in other studies. Each of these types of accidents will be discussed in the following subsections with regard to the damages caused and the magnitude of associated risks.

(a) Lock and Dam Accidents

Several studies have been conducted for the Corps which address the fire risks at navigation locks and dams on the inland waterways system. These studies indicate that potential damages from accidents at locks and dams are among the largest for any type of waterways accident. An early study [31] examined McAlpine Lock and Dam on the Ohio River at Louisville, Kentucky. Other locks and dams (L/Ds) cited in the McAlpine study with the potential for major damages are:

1. Lock and Dam 15, Mississippi River, Rock Island, Illinois.

2. Lock 27, Mississippi River, Granite City, Illinois.

3. Peoria Lock and Dam, Illinois River, Peoria, Illinois.

4. Brandon Road Lock and Dam, Des Plaines River, Joliet, Illinois.

5. Greenup Lock and Dam, Ohio River, Greenup County, Kentucky.

Assuming worst case conditions at McAlpine, an hypothesized maximum casualty at the 1,200-foot lock was estimated to cause $6.5 million in total losses, including $750,000 in direct damage to the lock, once every 52 years. It was assumed that six super jumbo tank barges (295' x 52') catch fire in the 1,200-foot lock, with the fire spreading to a tow waiting downstream with two empty gasoline barges.

Under a similar scenario, the maximum loss involving the dam (and loss of pool) was estimated at $53.9 to

$153.9 million, of which $2 million represented damage to the dam itself. This scenario has the same six barges break loose in high current above the Louisville & Portland Canal, resulting in two barges wedged and burning in the dam gates, three others passing over the dam, one barge crashing into the hydroelectric plant, and the towboat washed onto the embankment. As extreme as they appear to be, elements of these situations have occurred in the past at McAlpine Lock and Dam.

A recent fire risk analysis study [32] by the same firm examined Dresden Island Lock and Dam Site on the Illinois Waterway. Current fire protection practices at existing lock and dam sites on the Inland Waterway System were reviewed. Responses were received from all Corps of Engineers Divisions in the Continental United States, as well as most districts with inland river systems. Louisville and Nashville were the only districts in which fixed fire protection systems (water spray) were installed to protect the lock miter gates. None of the districts had fire protection systems installed which would be effective in controlling a major fire in the lock chamber.

The estimated costs of a tanker barge fire occurring at the Dresden Island lock or dam were determined. The "moderate" fire scenario envisions a fire which does not spread beyond the vessel of origin to other vessels in the tow. Under the moderate damage scenario, direct losses were estimated at $356,000 to government property and $560,000 to the tow. However, indirect losses were estimated at $3 million, due to a 30-day closure of the lock for repairs.

The "maximum" expected fire or catastrophic fire would occur when the fire spreads beyond the vessel of origin to other vessels in the the tow. The maximum damage scenario direct losses were estimated as $3.304 million to government property and $7.985 million to the tow; indirect losses totalled $15 million, due to a 150-day closure. Frequency of all tanker barge fires at the lock was estimated as 6.4 accidents per 100 years.

Indirect damages to businesses that rely on the Illinois Waterway for transportation were determined by interviews with waterways users. It was found that the

user costs caused by a long closure of the waterway to traffic would be in the range of $1 to $2 per ton of material which would normally have been shipped. This finding is in agreement with a previously conducted Corps of Engineers study on the cost of an unannounced closure of the Illinois Waterway, which determined that the cost of closing the waterway was approximately $1.50 per ton of goods which normally would have been shipped.

A catastrophic fire loss potential exists at an unprotected lock or dam. Should a fire occur in a tanker barge or a towboat while in or near the lock chamber, and not spread to other vessels, the damage caused is expected to be moderate and limited to the lock gates and vessels. Injury to deck hands on the vessel of origin, and possible injury to lockmen on the lock wall and other tow crew members is likely. Should the fire occur in the lock chamber while it is empty or nearly empty, the entire tow crew will be in danger, as they have no readily available means of escape. The lock chamber may fill with carbon monoxide or other toxic combustion products, impairing the crew members' physical or mental abilities. Crew members and lockmen or fire fighters who attempt to rescue the tow crew may be overcome by the toxic combustion products present in the lock chamber.

Accident statistics do bear out the hypothesis that once an incident occurs at the dam, the loss is great. A review of previous accidents at McAlpine indicated that the magnitude of the average loss at the dam exceeds ten times the average loss at the lock.[31] Accessibility to a dam is often limited, making retrieval of a barge difficult. This presents a particularly hazardous situation when a barge is wedged in a dam gate, preventing it from being closed. If loss of pool results, consequences will be proportional to the industries and municipalities affected.

Selected conclusions from the McAlpine Lock and Dam study [31] are applicable to other sites, and they indicate the types of risks associated with lock and dam accidents in general:

1. Accident frequency is greater at the lock than at the dam, but the magnitude of the average loss at a dam is greater than the magnitude of the average loss at the lock.

2. The loss potential for persons and property not under the jurisdiction of the Corps of Engineers is substantially greater than the loss potential to Corps of Engineers property.

3. There is considerable potential for life loss; this potential is greater at the lock than at the dam.

4. The loss potential of an incident involving the loss of pool is far greater than that where the pool is not lost. Loss of pool through an incident at the lock is unlikely, although the time to repair lock gates damaged in an incident could cause considerable delays. Structural conditions and the availability of emergency bulkhead closure systems influence the likelihood that pool would be lost at a specific facility.

5. The magnitude of a loss at a lock can be reduced by the installation of protective systems. The risk level may be reduced by changes in the surrounding environment.

(b) Bridge and Pier Rammings

Although no published studies of the risks associated with rammings are known to be available, it is possible to describe in general the types of losses which can be expected in a ramming. The two most common losses are vessel and structural damages resulting from the impact. United States Coast Guard statistics for FY 78 indicate that losses to vessels averaged $24,700 per ramming accident, while other property damages (which would include the structure) averaged $18,900. Estimated cargo losses were under $3,000 per accident.

Case studies of casualties involving rammings indicate that the vessel's structure usually buckles, with rupture likely. Protective systems on the pier or bridge usually are damaged, with the extent of damage proportional to the size and speed of the vessel. In certain circumstances, a bridge will collapse after a ramming, thereby closing the bridge and/or channel. Such situations have occurred at the Sunshine Skyway bridge at the entrance to Tampa Bay, the Chesapeake Bay Bridge Tunnel, the Hopewell, Virginia

bridge over the James River, the Lake Ponchartrain Causeway, and the Southern Pacific Railroad bridge at Morgan City, Louisiana. In the latter case, which occurred on April 1, 1978, the bridge repair costs were more than $1 million, and traffic on the railroad mainline was disrupted for eight days.[33] Other losses resulting from rammings typically involve spills of bulk liquids or vessel fuel.

Personnel injuries are normally minor in rammings. Over the last ten years, Coast Guard reports show there were usually about five injury-causing rammings annually for a yearly total of two deaths and six injuries, although in FY 73 there were nine casualties which caused 19 deaths and ten injuries. When tows are involved in rammings on rivers, a common outcome is for barges to break away and drift downriver. The barges are usually stopped by other towboats or become grounded with minimal damage, but in some cases they ram other vessels or structures, or become grounded and suffer structural damage.

High risk factors associated with rammings are fires, explosions, hazardous materials spills, and the release of toxic chemicals whenever the vessel is severely damaged. These risk factors are dependent upon the extent of vessel damage, the type of commodity being carried, and the location of the accident. A few years ago, a barge on the Ohio River broke loose of its tow while moving upstream in high water. The barge drifted downstream and rammed the Baltimore & Ohio Railroad bridge at Belpre, Ohio/Parkersburg, West Virginia. The ensuing fire was of sufficient intensity to cause structural damage to the bridge, placing it out of service until emergency repairs could be made.[31] The accident occurred in a populated area, and the barge could have struck a nearby oil refining company dock, with potentially greater losses. Toxic chemical releases, such as chlorine gas, are a major risk because bridges and piers are normally associated with populated areas, thereby increasing the potential population exposure.

Additional risks are associated with pier and dock rammings when a terminal handles such bulk hazardous materials as chemicals and petroleum products. These

terminals have pipeline connections which can be ruptured, leading to fires, explosions and spills. In some cases, the fire can spread to storage tanks in the terminal area. Such an incident occurred at an oil refinery terminal in Philadelphia when the pier was struck by a tanker. The resulting fire destroyed the ship, the pier facilities, and some of the storage tanks.

(c) Collisions and Rammings Between Vessels

A review of vessel casualty case studies and newspaper reports of accidents where moving vessels collided, or where a moving vessel rammed an anchored vessel, indicates that the types of risks are similar to those associated with bridge and pier rammings. On average, estimated losses from such casualties in FY 78 were $41,300 per incident ($14,700 per vessel) in vessel damages, $17,100 per incident in cargo damages, and $5,100 per incident in other property damages. These statistics reinforce the observation that most damages are to the vessels involved and their cargo. Structural damage to at least one vessel usually occurs when vessels collide, often rupturing cargo or fuel tanks and leading to a spill. Vessel founderings or capsizings can also result. Loss of vessel control may occur, which can lead to further rammings of piers, bridges, navigation aids, or other fixed objects.

Onboard personnel casualties occur in under 10% of vessel collisions, but casualties can be high when a major fire erupts or a vessel sinks. Of the major risks associated with collisions fire is the most prevalent, although explosions, hazardous materials spills and toxic chemical releases are also of concern. An additional risk factor is the potential closure of shipping channels whenever a vessel sinks after collision, as occurred after the collision between the tanker Capricorn and the United States Coast Guard Cutter Blackthorn in Tampa Bay on January 28, 1980.

(d) Explosions and Fires

Waterways accidents in which a fire or explosion occurs are normally associated with collisions, rammings,

and (to a lesser extent) groundings. However, there are situations where explosions and fires occur for other reasons. United States Coast Guard data indicates that the most common situation is for a small fire of undetermined origin to erupt on a fishing vessel, tug, or towboat, with the fire eventually put out before the vessel is totally destroyed. However, in FY 78 fires and explosions resulted in the total loss of 38 vessels.

Estimated damages in all fires and explosions reported to the Coast Guard in FY 78 averaged $130,000 per incident in vessel damages ($119,200 per vessel), $14,700 per incident in cargo losses, and $50,900 per incident in damage to other property, which gives fires and explosions the highest average losses of any type of vessel casualty. Personnel casualties associated with these accidents totalled 18 deaths and 31 injuries in FY 78.

Explosions and fires represent a type of risk where damages and personnel casualties can be very large in a single accident, but the probability of such accidents is relatively small. The greatest risks occur when tankers are loading or unloading at terminals, because explosive vapors are present and the amount of materials that can become involved is large. Examples of such explosions are the Liberian tanker Sansinena at Long Beach, California on December 17, 1976; the Liberian tanker Seatiger at Port Neches, Texas on April 19, 1979; and the United States tanker Chevron Hawaii at Deer Park, Texas on September 1, 1979. The risk of a vessel fire spreading to general cargo terminal facilities also exists, but to a much lesser extent.

(e) Groundings, Sinkings, and Collisions With Floating or Submerged Objects

Most groundings result in minor damages, because vessel speeds are usually low and the bottom is usually soft material. Based on FY 78 data, about 58% of groundings had minimal associated damages. When the vessel was damaged, the losses to vessels averaged $96,500 per accident ($59,000 per vessel), cargo losses averaged $9,700 per accident, and other property damages were only $1,600.

Typically, personnel injuries and deaths are very low in groundings: about seven injuries and three deaths per year for all groundings over the last decade. Although Coast Guard summaries do not indicate similar information for collisions with floating or submerged objects, case studies show that damages are similar to those associated with groundings, although the probability of the vessel sinking appears to be higher.

For vessel sinkings (foundering, capsizings, and floodings), FY 78 statistics show damages to vessels averaged $62,100 per accident ($49,900 per vessel), cargo losses averaged $2,100, and other property losses averaged $2,400. Personnel suffered 119 injuries and 15 deaths in the same period, which reflects a large loss rate among fishing and other small vessels. One hundred and seven vessels of all types were totally lost in FY 78. About 3% of FY 78 sinkings were caused by the vessel striking a floating or submerged object.

The most significant risk associated with these types of waterways accidents is liquid cargo spills. Damage to the vessel is normally on the hull bottom, which almost eliminates the risk of fire. In certain conditions, the channel can be blocked by a vessel which grounds or sinks, although this is not common. Recent major accidents in this category include the breakup and sinking of the tankship *Chester A. Poling* near Gloucester, Massachusetts; the grounding and breakup of the *Argo Merchant* near Nantucket; and the foundering of the bulk carrier *Edmund Fitzgerald* in Lake Superior.

(f) Other Types

The other major grouping of vessel casualties involves material failure of the vessel structure, equipment, or machinery. Damages from such accidents typically are limited to the vessel or its cargo. Such accidents include swinging a container against the shipside during loading, engine or steam plant failures, propeller damage, and cargo pump failures. The risks associated with such accidents are small, unless they ultimately lead to a collision, ramming, explosion, or other type of major casualty. However, personnel injuries and deaths do occur fairly often in these types of accidents.

One other risk not associated with a particular type of accident bears notice. Pipelines carrying flammable or otherwise hazardous materials cross many inland and coastal waters. Offshore natural gas and petroleum drilling platforms and pipelines are present in the Gulf Coast, near Southern California, in Alaska's Cook Inlet, and may appear in Atlantic coastal waters. If such structures or pipelines should be struck or ruptured by a vessel or its anchor, there is a high risk of fire. Pipeline crossings near populated areas add to the level of risk associated with this situation.

PHYSICAL ASPECTS WHICH CONTRIBUTE TO ACCIDENTS

The studies of vessel control accidents on the inland waterways [29] and in harbor areas [30] indicate that the physical design and other features of the system are strongly associated with such accidents. A review of the 1977-1978 United States Coast Guard vessel casualty records was conducted to verify the relationships. Imprecision in coding of accidents in the Gulf coastal areas to specific waterways segments blurs the picture somewhat, but it is clear that the five cited waterways still account for the majority of inland accidents. Our observations are presented by major waterway segment.

1. Gulf Intracoastal Waterway - West. Many collisions occur at bends and intersections (especially near Galveston, Port Arthur, Lake Charles, Morgan City, and Houma), rammings occur at locks and floodgates, and there are frequent bridge rammings (especially near Galveston, Morgan City and Houma). Groundings are a problem at sections through shallow bays, and at bends and intersections.

2. Lower Mississippi. Collisions occur primarily near the mouths of the Mississippi and in the New Orleans port area. Bridge rammings at Natchez, Vicksburg, and Greenville are frequent. Groundings are primarily at bends and locations where the channel is unstable. The St. Louis area is notable for rammings.

3. Upper Mississippi. Bridge rammings are typically at narrow movable spans. The Quad Cities area stands out as a high accident area with bridges, Lock and

Dam 15, and industrial docks located close together. Groundings are clustered near the mouths of tributary rivers and locations where the channel twists.

4. Illinois Waterway. Bridge rammings occur at a few narrow movable spans (especially at Pearl, the Peoria/Pekin area, the Hennepin/La Salle/Peru/Ottawa area, and the Joliet/Lockport area). Groundings cluster near Marseilles, Morris, and the mouth of the Kankakee River.

5. Ohio River. Accidents most frequently occur at locks, especially the older, smaller facilities. Gallipolis has the highest accident rate on the river. The entire section from Newburgh Lock and Dam to Cairo has a high vessel control accident rate. The Louisville area also has a high accident rate.

6. Gulf Intracoastal Waterway - East. A high vessel control accident rate exists in the New Orleans port area. Groundings occur in land cuts and near shallows of bays. Bridge rammings stand out at New Orleans, the Bay St. Louis area and at Dauphin Island near Mobile. (The Dauphin Island bridge was destroyed by Hurricane Frederic.)

7. Tennessee River. A high number of rammings occurs at the Decatur, Alabama, bridges and at bridges on the lower end of Kentucky Lake where the water surface is wide.

8. Arkansas River. A high rate of rammings and groundings occurs in the lower section from Lock and Dam 2 to the mouth.

All of the 35 high accident 10-mile sections noted by the inland system study [29] show up as high accident areas in the 1977-1978 data.

Coast Guard coding techniques for the coastal and Great Lakes areas do not permit accurate identification of accident locations. However, a quick review of the 1977-1978 data indicates that accidents in these regions are concentrated in a few areas, typically the high traffic deep-draft ports. The most notable locations were New York; the Delaware River; Baltimore; Hampton Roads; Morehead City, North Carolina; near Cape Fear, North Carolina;

Tampa; New Orleans; Port Arthur/Beaumont/Orange; Houston/Galveston; Corpus Christi; Los Angeles/Long Beach; San Francisco Bay; Coos Bay, Oregon; the lower Columbia River; Seattle; the St. Mary's River (Soo Locks); Ketchikan, Alaska; and San Juan and Guayanilla Bay, Puerto Rico.

One very noticeable change has been an increase in the number of reported groundings throughout the system. Figures IV-B through IV-F show the number of vessel groundings, collisions between moving vessels, and rammings of fixed objects (piers, bridges, locks) reported by the Coast Guard in its annual statistical reviews for Fiscal Years 1969 through 1978. Data has not been adjusted to reflect the 15-month reporting period for FY 76 and the Transition Quarter. Possible explanations for the notable increases in groundings include expanded reporting requirements, greater vessel traffic, or less channel dredging. Most likely, all of these are contributing factors.

Evidence is strong enough to make the following associations between waterways system accidents and the physical characteristics of the system. Channels where current and (to a lesser extent) wind effects are strong and subject to variation tend to cause vessel control accidents. Such accidents occur because vessel maneuvering in such a situation is difficult to execute with precision, due to poor knowledge of effects and unstable vessel response characteristics at low speeds. Current effects are most noticeable at bends, intersections, bridges, dams, industrial water intakes and discharges, narrow channels, and in water subject to tides. Most frequently, wind affects lightloaded vessels with high freeboards, and is most noticeable on bays and reservoirs where wind can move unhindered for long distances. Many times current or wind will cause a towboat to lose all maneuvering control, and the forces exerted on the barges can then break the lashings.

Bridges also contribute to vessel control accidents, especially when the available horizontal clearance is limited. Whenever the horizontal clearance is less than twice the width of the typical tow or vessel, rammings are highly likely. Bridges which are placed at an angle to the sailing line other than 90° tend to have more accidents, because vessels must perform a flanking maneuver.

FIGURE IV-B

VESSEL CASUALTIES
INLAND ATLANTIC

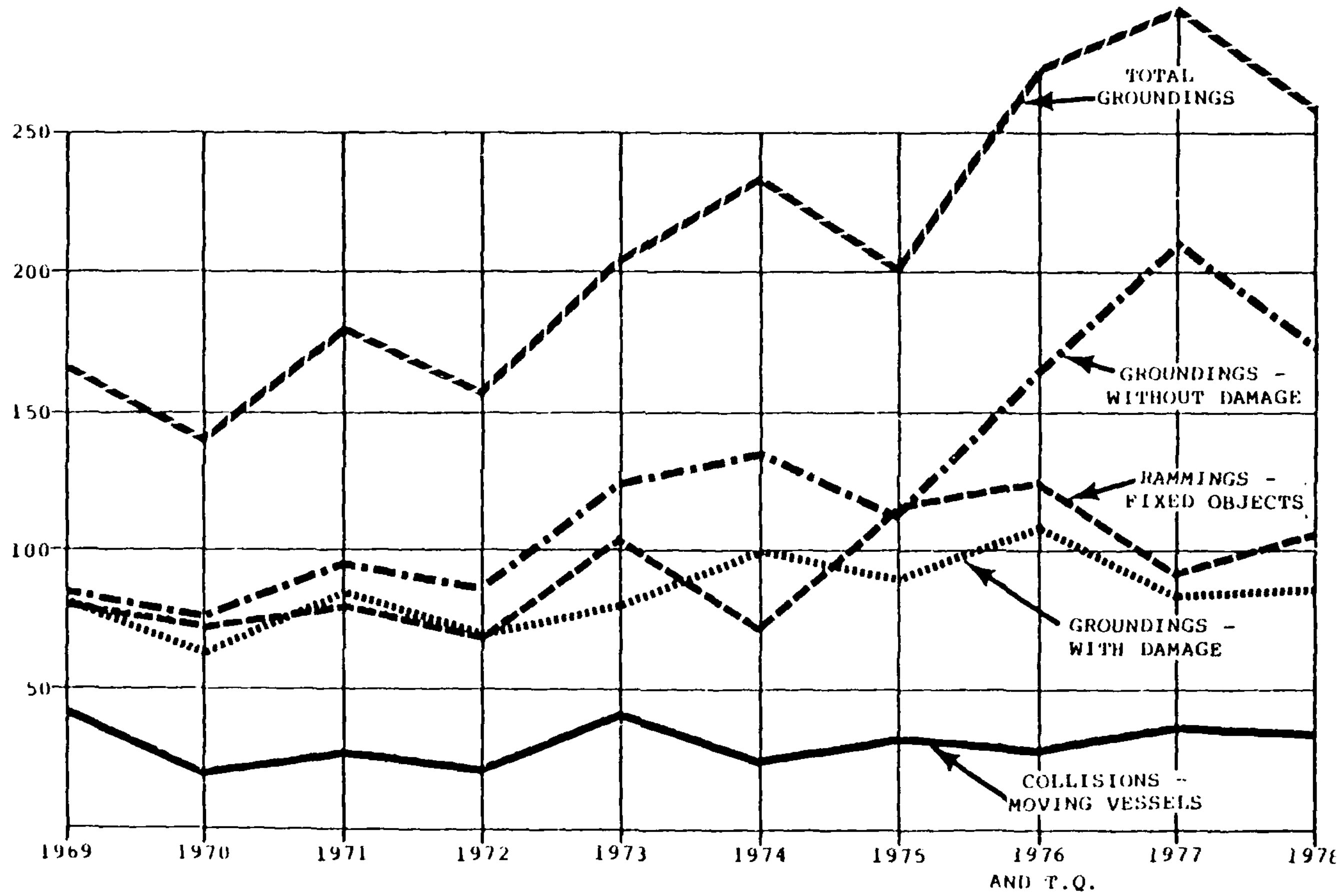


FIGURE IV-C

VESSEL CASUALTIES
INLAND GULF

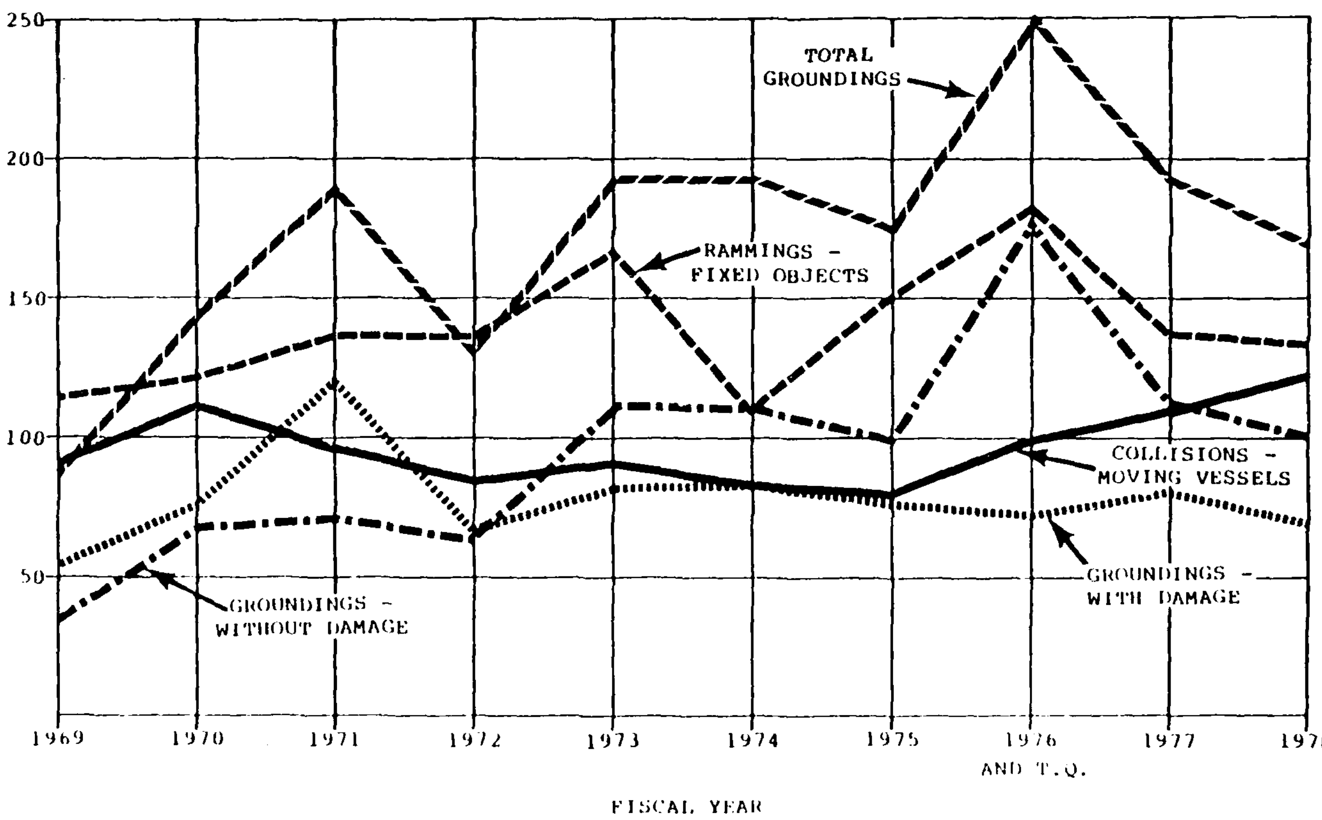
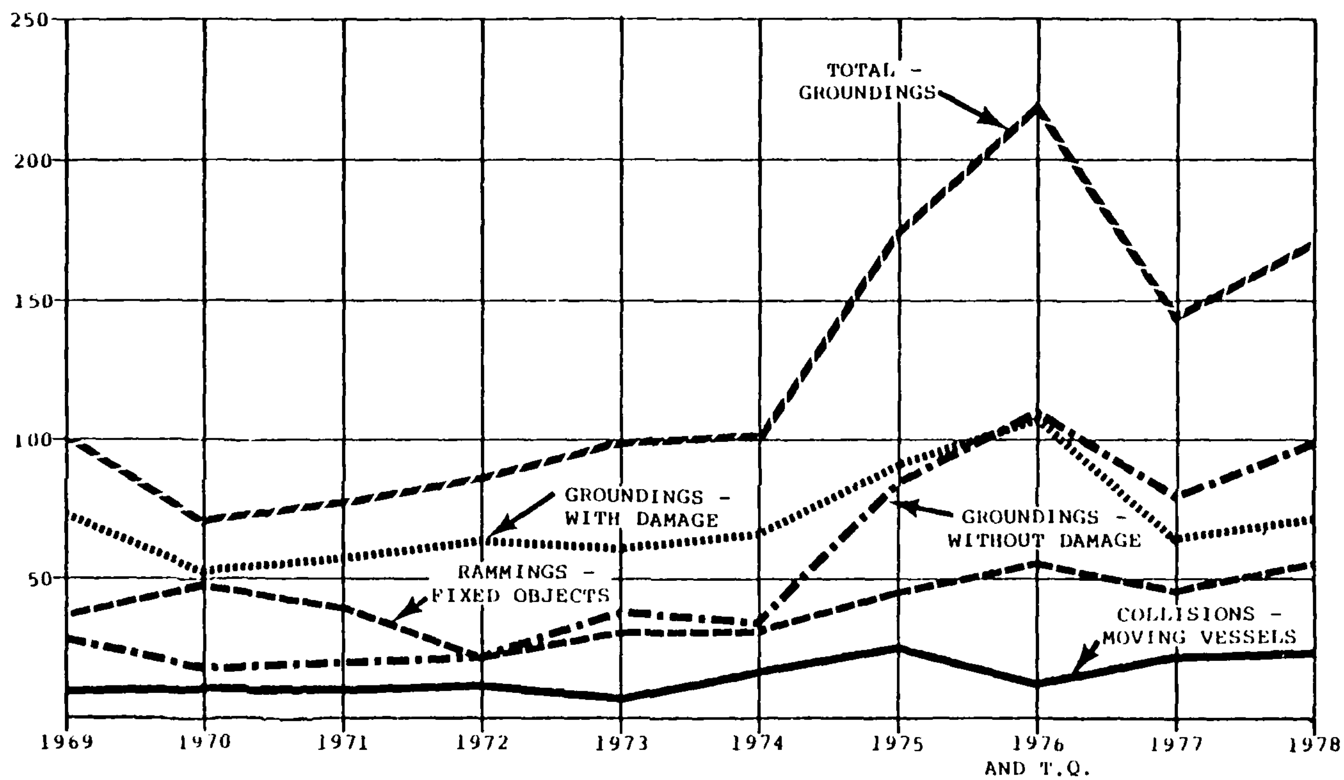


FIGURE IV-D

VESSEL CASUALTIES
INLAND PACIFIC



FISCAL YEAR

FIGURE IV-E

VESSEL CASUALTIES
WESTERN RIVERS

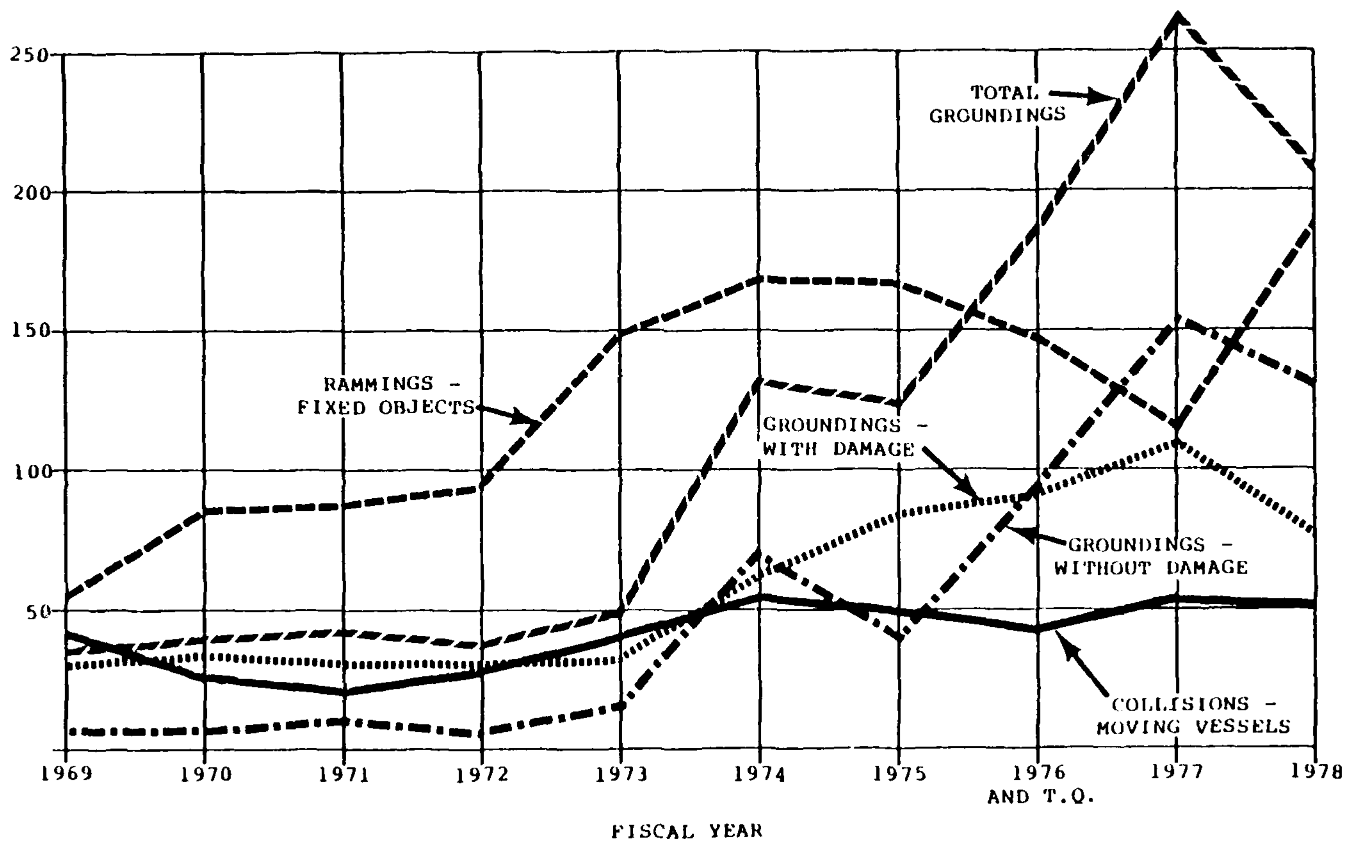
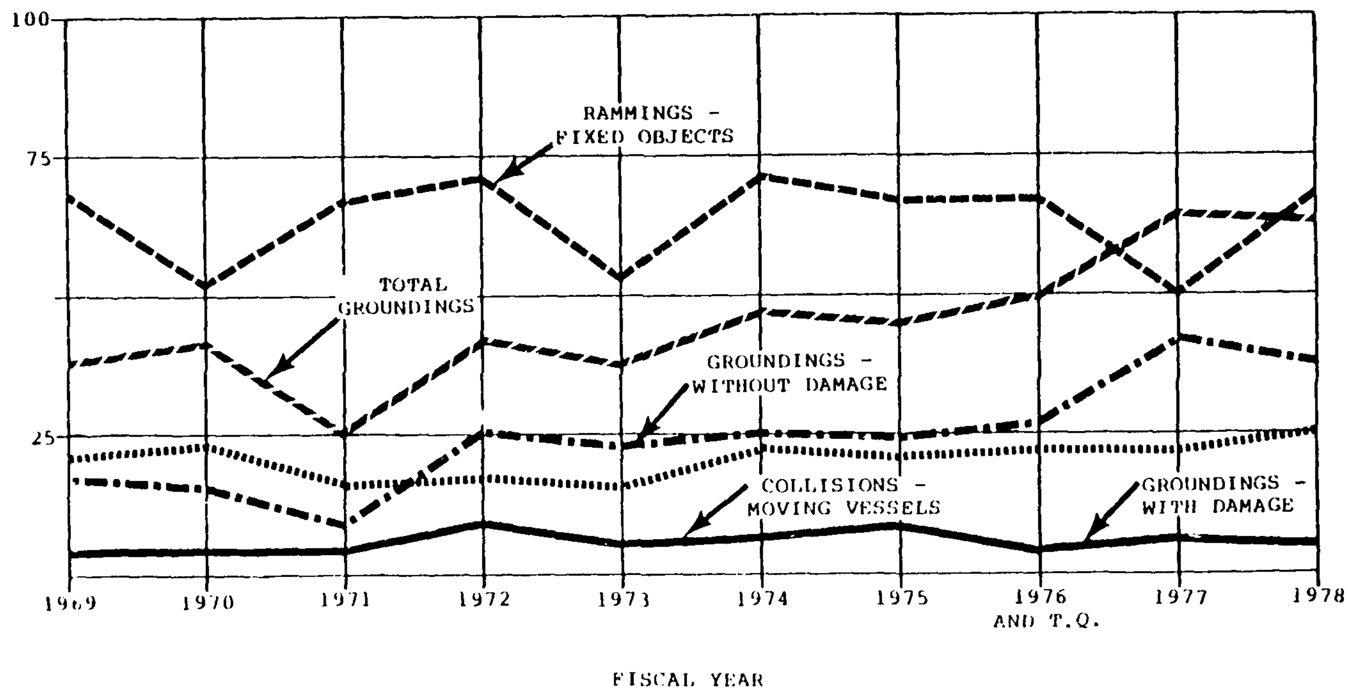


FIGURE IV-F

VESSEL CASUALTIES
GREAT LAKES



Movable bridges are a special problem because their horizontal clearances are typically narrow, and because a failure to open in time can cause the vessel to strike the overhead span.

Locks present a navigation hazard because most tows are just slightly narrower than the available lock width. If the vessel approach is not relatively straight, the lock structure can easily be rammed. The tight navigation situation at a lock is compounded by the "shoving" effect from the current on downbound vessels, and the tendency for upbound barges to "dive" in the swirling currents below the dam. Underpowered towboats are susceptible to collision with the lock during entry and exit.

Channel configuration is a contributing factor for two reasons: it influences the current forces, and can obscure the vision of the person-in-charge. Features most strongly associated with accidents are bends, intersections and narrow channel widths. The high vessel casualty rate on the GIWW-West is, to a large extent, created by a channel configuration inadequate for current traffic demands.

Another contributing factor is a rapidly changing water stage, because it tends to shift the channel and deposit silt. Other notable features which cause accidents are sunken vessels, submerged portions of old locks or bridges, and inadequate or missing navigation aids.

PORT MARINE SAFETY AND FIRE FIGHTING

The United States House of Representatives Committee on Merchant Marine and Fisheries recently issued a report which examines port safety.[34] Relevant information from the report follows.

Ports have traditionally evolved as extensions of state and local governments, drawing upon those entities for necessary services, such as police and fire protection. The federal role in port development stems from an understanding reached in 1789 and embodied in the federal

Constitution between the states and the new national government. The states yielded the power to tax interstate commerce in exchange for a commitment of federal assistance to improve the navigability of ports and waterways.

The Ports and Waterways Safety Act of 1972 broadened Coast Guard statutory authority over marine traffic management and the safety of port operations and waterfront facilities, while expressly reserving to the states the authority to require higher standards for safety and equipment for waterfront facilities. The Port and Tanker Safety Act of 1978 elaborated and specified federal responsibilities in the nation's ports and waterways, finding that "advance planning is critical in determining proper and adequate protective measures for the nation's ports and waterways and the marine environment..."

Following several major maritime disasters, Congressional initiatives were launched in the 94th Congress. House Report 11459 proposed the establishment of a national maritime fire fighting program, along the lines of the National Contingency Plan mechanism for oil spill cleanup and containment. The heart of this measure was the regional marine fire fighting concept, calling for the establishment of a highly trained, mobile marine firefighting team to supplement local municipal fire companies.

Hearings on this bill were held by the Merchant Marine Subcommittee during the period June-September 1976. These hearings revealed a pronounced trend toward the rapid deterioration of marine fire protection in major port cites. Factors cited were funding cutbacks caused by declining local tax revenues, technical obsolescence of the World War II tugboats which form the backbone of most marine fire fighting organizations, changes in the marine environment such as container terminals and larger tankers, and major local funding requirements for other federally-mandated programs for environmental protection, occupational health and safety, and cargo security.

This Congressional initiative stimulated the Maritime Administration to conduct a pilot program in marine fire

fighting with the Port of Seattle. The program proved the effectiveness of training land-based personnel in marine fire fighting in assistance of ship's companies. A companion effort resulted in the development of a prototype fireboat with high speed, and an articulated arm capable of fighting fires aboard tank vessels with high freeboard.

The "Seattle Plan" was introduced as House Report 362 in the 95th Congress, and was the subject of Coast Guard Subcommittee hearings during the period July, 1977 through July, 1978. During the course of these hearings, the Maritime Administration conducted a study which discounted the utility of the regional fire fighting concept, and concluded that the most cost effective strategy is the development of local marine fire fighting expertise in landbased fire fighters. The report documented over 220 vessel fires a year aboard United States vessels, finding that 61% of these fires occur pier-side. The report also found that 65% of port city fire fighters in the United States have no training in marine fire fighting.

This series of hearings documented the need to improve the marine disaster response capability in deep-draft ports. The Committee on Merchant Marine and Fisneries decided to build upon the categorical grant approach of House Report 362, substantially revising the legislation for reintroduction and consideration in the 96th Congress. This legislation was submitted as House Report 2994 on March 15, 1979.

Envisioned is a two-tiered grant approach requiring the preparation of a comprehensive port safety contingency plan prior to the submission of an application for additional assistance for equipment, and the training of personnel through implementation grants. The duration of federal assistance is limited, but grant eligibility has been extended to include both municipalities and public agencies (including interstate agencies). The bill authorizes $20 million for port safety planning grants, $75 million for port safety implementation grants, and $1 million for a port user fee study.

Hearings on House Report 2994 were held by the Subcommittee on Coast Guard and Navigation on April 26-27,

1979. Broad public concern was expressed for the safety of local ports and waterways, and the provision of adequate disaster response capability in the event of major marine casualties. The Port of Long Beach described its port safety planning effort, which utilizes coastal energy impact program funds to identify, measure, and document existing and potential hazards in that Port, and to identify and evaluate existing contingency measures, regulations and plans for marine disaster response. Testimony pointed to a pending national crisis in deteriorating marine fire protection across the country.

The Administration's reaction to the legislation was provided by a representative of the Coast Guard, and by written comments submitted by the Assistant Secretary of Commerce for Maritime Affairs. The Coast Guard witness supported the development of port disaster contingency plans and maintenance of adequate disaster response capability, but emphasized that the Administration's position is that the responsibility for performing and funding these programs is primarily a local obligation. The Maritime Administration supported the need for external assistance to improve commercial port safety, but disavowed the propriety of federal assistance in this area [34, 35, 36].

The Executive Director of the American Association of Port Authorities (AAPA) indicated that many ports would be interested in a study of better means and mechanisms for them to recapture the costs of providing local port safety services. Several witnesses alluded to the analogous means of providing safety services in highway and commercial air transportation, through some variation of the trust fund concept adapted to the commercial port operational setting. AAPA disagrees with the level and time limit on the grants, and opposes any study of user-fees to recover the costs of safety services.

Comments received after the hearings expressed a strong interest in expanding the scope of House Report 2994 to include inland ports. This involves a question of committee jurisdiction, since the House Commerce Committee exercises oversight of inland ports and waterways. Future hearings will be held to determine the ultimate levels of funding, the cost-effectiveness of the proposal, to

resolve jurisdictional issues, and to resolve the need for a user-charge study. At a minimum, the hearings have indicated that major efforts are needed to upgrade existing port safety plans (to include land use issues), and to upgrade port fire fighting and disaster response capabilities.

STRATEGIES TO REDUCE ACCIDENTS

Potential strategies for reducing waterways accidents which have been identified by the ORI studies [29,30] are of four types:

1. Personnel training and licensing.

2. Structural improvements to the waterways system.

3. Alteration of operating procedures.

4. Improvements to vessels and their equipment.

An action which by itself could reduce accidents is the improvement of the waterways system, thereby eliminating or mitigating hazards to navigation. The other strategies allow more effective response to hazards through improved identification or vessel control. Some specific types of actions which can be undertaken within each of these strategies will be discussed below.

In an effort to reestablish and improve coordination between the United States Coast Guard and the shallow-draft navigation industry, a Towing Safety Advisory Committee was established by Public Law 96-380, adopted on October 6, 1980. The Committee will consist of sixteen members appointed by the Secretary of Transportation who have particular expertise, knowledge, and experience regarding shallow-draft inland coastal waterway navigation and towing safety, as follows:

1. Seven members from the barge and towing industry, reflecting a regional geographic balance;

2. One member from the offshore mineral and oil supply industry; and

3. Two members from each of the following:

    (a) Port districts, authorities, or terminal operators;

    (b) Maritime labor;

    (c) Shippers (of whom at least one shall be engaged in the shipment of oil or hazardous materials by barge); and

    (d) The general public.

The Secretary of Transportation may request the Secretary of the Army (Corps of Engineers) and the Secretary of Commerce (Maritime Administration) to each designate a representative to participate as an observer on the committee.

(a) Personnel Training and Licensing

United States Coast Guard vessel casualty data, shipper/carrier interviews, and several studies have identified human error as the single largest cause of waterways accidents. Although some studies, as well as personal opinions, have pointed to greater accident rates among less skilled operators, no study has conclusively established this relationship.

Most operators acquire skills through informal on-the-job training, which emphasizes development of personal knowledge of the environment and vessel response characteristics. Uncertainty of navigation conditions is thus a normal situation for the vessel operator. Vessel accident records indicate that most human errors occur not because of negligence but because of failure to adequately assess the navigation situation.

This conclusion suggests that an effective accident reduction strategy would be to develop and disseminate better information about vessel response characteristics in difficult situations. A program involving theoretical

research on the vessel control effects due to winds, tides, currents, and shallow water could be conducted, with results made available to the marine industry.

Personnel action failures also are an important factor in accidents, especially in collisions and in spills of hazardous materials. Training and licensing programs should emphasize the proper actions to take in both normal and unexpected situations, and should cover both vessel crews and terminal workers. Current United States Coast Guard licensing programs for crew members who handle hazardous materials require demonstration of skills before a license is issued. Another direction to take would be a review of operating rules and regulations to eliminate confusing or ambiguous language. Additional research into the causes of human error is also a viable strategy.

Personnel training programs have increased lately with the opening of the National River Academy at Helena, Arkansas and the establishment of maritime union training programs. These programs have been started in response to safety, personnel turnover, insurance cost and pollution liability problems. However, these efforts have not always been coordinated and industry support has not always been enthusiastic; these problems may remain in the future.

Federal assistance to industry-union schools was about $39.5 million from 1950 to 1975, while assistance to state maritime academies was about $37 million in the same period. A maritime education bill (House Report 5451) was passed by the House on June 30, 1980. Nine separate acts relating to maritime education would be consolidated into a single recodified act. Additionally, it would define the primary function of the United States Merchant Marine Academy and the State maritime academies, establish uniform service obligations for Merchant Marine Academy graduates, and revise and expand student financial assistance programs. Senate passage is unlikely in this session, but the bill will be introduced and revised during the 97th Congress.

Another option for improving marine navigation training is the use of real-time vessel simulators. At pre-

sent, the only full-scale simulator is the Computer Aided Operations Research Facility operated by the United States Merchant Marine Academy exclusively for research purposes. Although costs are high, many industry people view simulators as extremely valuable training devices. Arthur Friedberg, Director of MARAD's Office of Maritime Labor and Training, told Congress that "These devices represent probably the most significant advancement in the training of a deck officer that we've seen," citing the capability to program a simulator to reproduce emergency situations. [37]

(b) Structural Improvements

The minimization of channel obstructions and variations is the goal of structural improvements to the waterways system. Structural aspects of the system most frequently associated with accidents are bends, intersections, junctions, bridges, piers, locks and submerged objects (sunken vessels, shoals, old bridge piers, old locks, etc.). Each type of hazard lends itself to certain strategies for reducing accidents.

1. Bends, Intersections, Junctions. Channel bends, intersections, and junctions are associated with groundings and collisions. Groundings occur in these locations because of currents which force vessels "out of shape" and because of shoaling. Current effects are difficult to cope with given existing technology. Research into methods to stabilize or control currents may be appropriate, as would be a program to develop current force measuring devices for vessels, and improved steering systems at low speeds.

Shoaling can be reduced through dredging or channel training projects, as well as by soil conservation and other non-waterway programs. With respect to collisions, some situations may warrant reconstruction or realignment of the channel to eliminate bends or increase visibility in the area. Other potential programs would encompass communication or operational changes, which are covered in more detail later.

2. Bridges. Bridges present a navigation problem because of span length, the orientation with respect to the channel, current patterns (especially near bends),

and the type of construction. These factors, as well as vessel traffic, rail/highway traffic, and the extent of alteration costs, enter into the determination of replacement needs for old structures and designs for new structures.

Currently, the United States Coast Guard is responsible for administering the bridge alteration program of the Truman-Hobbs Act, in which a nonfederal bridge can be altered or removed if it is found to be unreasonably obstructive to navigation. Legal responsibility for maintaining bridges over navigable waters in a manner which does not impede navigation is the responsibility of the owner. The Truman-Hobbs Act allows the federal government to share in alteration costs, to the extent of providing for replacement-in-kind. Betterments in the new structure must be paid for by the owner, with Section 6 of the Act specifically enumerating those costs which the bridge owner must bear.

Whenever a bridge must be altered or relocated in conjunction with a new navigation project, the Corps of Engineers is responsible for the work. In the recently adopted 33 CFR Part 277, the Corps adopted the principles of the Truman-Hobbs Act as the basis for determining federal costs for bridge alterations. It is important to note that neither program has a provision to assist bridge owners in meeting their share of bridge alteration costs.

Table IV-3 indicates appropriations by Congress for bridge alterations under the Truman-Hobbs Act. Responsibility for the program was transferred from the Corps to the Coast Guard in FY 68. Appropriation levels have varied, in part reflecting the relatively long time period required to complete major projects. Projects completed to date under the Truman-Hobbs Act are shown in Table IV-4, while those currently under construction, awaiting construction, or under investigation are shown in Table IV-5. Current annual program funding approximates the total costs for one major project.

Interviews with Coast Guard safety officers revealed several drawbacks to the current bridge alteration program. Funding is dependent upon annual Congressional appropriations, not a guaranteed funding program. Bridge owners must pay for such items as the expected savings in repair or maintenance costs (but not operating costs); increases in bridge carrying capacity or

other alterations attributable to the rail or highway traffic (even if required to bring the structure to federal standards); other betterments such as a heated operator's shed; the capital value of the expired service life of the old structure; and a share of the costs for engineering, removal of the old structure, and other fixed charges. Past project records indicate that owner costs are substantially higher for highway than for rail bridges.

Finally, the Truman-Hobbs program does not allow for the consideration of nonnavigation benefits during project evaluation, whereas other federal highway bridge programs recognize only highway traffic benefits. A situation occurred in Seattle, Washington, when a narrow highway movable bridge over a harbor channel could not be replaced under any existing program. After a ship rammed and destroyed the bridge, it took a special Congressional act to build a new bridge suitable for both highway traffic and navigation needs.

Table IV-3

Appropriations for Bridge Alterations
Truman-Hobbs Act

	Fiscal Year	Appropriation
Corps of Engineers	1941	$1,100,000
	1947	2,900,000
	1948	500,000
	1949	500,000
	1950	100
	1956	3,467,000
	1957	4,300,000
	1958	3,020,000
	1959	6,923,558
	1960	9,641,000
	1961	2,306,000
	1962	500,000
	1963	500,000
	1964	1,900,000
	1965	1,713,000
	1966	3,224,000
	1967	3,600,000
Coast Guard	1968	3,800,000
	1969	5,800,000
	1970	9,404,000
	1971	-
	1972	9,750,000
	1973	12,500,000
	1974	4,000,000
	1975	6,800,000
	1976	6,500,000
	T.Q.	1,625,000
	1977	10,900,000
	1978	15,100,000
	1979	14,900,000
	1980	7,650,000
	1981(1)	16,000,000

NOTE: (1) As proposed in FY 81 budget request (_Traffic World_, February 4, 1980).
T.Q. - Fiscal Year 1976 Transition Quarter.

SOURCE: United States Coast Guard.

Table IV-4

Completed Bridge Alteration Projects
Truman-Hobbs Act

Current Owner	Location	Waterway	Date Completed	Total Cost	Federal Share
Southern Pacific Railroad	Mermentau, LA	Mermentau River	April, 1944	$ 403,733	$ 332,394
Kansas City Southern Railroad	Beaumont, TX	Neches River	November, 1946	479,037	325,625
Southern Railway	Jackson, AL	Tombigbee River	August, 1951	1,637,117	1,019,018
Beaufort & Morehead Railroad	Beaufort, NC	AIWW	Mid 1952	369,589	334.263
Chicago & North Western Railroad	Leavenworth, KS	Missouri River	Mid 1952	60,575	57,990
Seaboard Coast Line Railroad	Savannah, GA	Savannah River	May, 1952	1,609,544	1,445,003
Seaboard Coast Line Railroad	Fernandina Beach, FL	Kingsley Creek (AIWW)	August, 1953	457,735	443,850
Burlington Northern Railroad	Quincy, IL	Mississippi River	Mid 1957	9,545,954	2,348,954
Norfolk & Portsmouth Belt Line Railroad	Norfolk, VA	Elizabeth River	October, 1958	2,616,000	2,230,000
Southern Pacific Railroad	Los Angeles, CA	West Basin	April, 1958	133,000	115,000
Interstate Highway 5	Vancouver, WA	Columbia River	December, 1959	2,402,200	1,114,000
Norfolk & Western Railway	Valley City, IL	Illinois River	Mid 1960	4,281,950	2,654,195
Highway 26/Soo Line Railroad	Houghton, MI	Keweenaw Waterway	May 1960	11,126,200	4,230,000
U.S. Highway 181	Corpus Christi, TX	Corpus Christi Channel	June, 1961	6,088,643	4,288,713
Chelsea Street	Boston, MA	Chelsea River	October, 1961	145,640	137,954
Ohio Street	Buffalo, NY	Buffalo River	May, 1962	4,000,000	2,760,000
Woodland Street	Nashville, TN	Cumberland River	December, 1966	1,811,000	1,063,000
Norfolk & Western Railway	Chicago, IL	Calumet River	June, 1970	6,104,034	5,871,800
Southern Pacific Railroad	Morgan City, LA	Berwick Bay	December, 1971	7,259,359	7,117,636
Chicago & Western Indiana Railroad	Chicago, IL	Calumet River	July, 1972	8,649,266	8,395,854
Seaboard Coast Line Reilroad	Wilmington, NC	N.E. Cape Fear River	August, 1973	4,127,830	3,927,560
Southern Railway	Columbia, AL	Chattahoochee River	August, 1973	3,307,409	937,192
Seaboard Coast Line Railroad	Alaga, AL	Chattahoochee River	November, 1974	2,143,532	1,997,225
Burlington Northern Railroad	Beardstown, IL	Illinois River	December, 1974	4,791,664	4,068,871
Norfolk & Western Railway	Norfolk, VA	Elizabeth River	December, 1974	5,446,762	5,231,969
Elgin, Joliet & Eastern Railway	Chicago, IL	Calumet River	March, 1975	8,107,868	7,372,708
U.S. Highway 84	Alaga, AL	Chattahoochee River	May, 1975	4,664,840	1,613,606
Union Pacific Railroad	Kennewick, WA	Columbia River	October, 1977	10,971,926	10,866,563
Seaboard Coast Line Railroad	Tice, FL	Calloosahatchee River	January, 1978	3,717,432	3,614,813
Seaboard Coast Line Railroad	Savannah, GA	Savannah River	September, 1978	11,038,270	8,629,165
Seaboard Coast Line Railroad	Charleston, SC	Cooper River	December, 1978	3,525,815	3,450,154

Note: (*) Demolition of existing structure only.

Source: U.S. Coast Guard.

Table IV-5

Current Bridge Alteration Projects
Truman-Hobbs Act

Owner	Location	Waterway
	Under Construction	
Southern Pacific Railroad	Brazos, CA	Napa River (Mile 7.8)
Milwaukee Road	Hastings, MN	Mississippi River (Mile 813.7)
Illinois Central Gulf Railroad	Pearl, IL	Illinois River (Mile 43.2)
Southern Pacific Railroad	Houma, LA	GIWW (Mile 59.6)
Central Railroad of New Jersey	Newark, NJ (*)	Newark Bay (Mile 0.7)
	Pending Construction	
Alabama State Docks Railroad	Mobile, AL	Three Mile Creek (Mile 0.7)
Cochrane Highway	Mobile, AL	Mobile River (Mile 2.9, Black Warrior-Tombigbee Waterway)
New Jersey DOT	Point Pleasant, NJ	Point Pleasant Canal (Mile 3.0)
Peoria & Pekin Union Railroad	Peoria, IL	Illinois River (Mile 160.7)
	Under Investigation	
Louisville Nashville Railroad	Clarksville, TN	Cumberland River (Mile 126.5)
Southern Pacific Railroad	Mermentau, LA	Mermentau River (Mile 68.0)

Note: (*) Demolition of existing structure only.

Source: U.S. Coast Guard

Bridge alterations are not the only effective method for reducing damages, as noted in a Waterways Journal article.[38] The high cost of vessel repairs, including cleaning and inspection costs for tank barges and vessels, represents a major cost for carriers. Many bridge protection systems are either inadequately designed for current traffic, are poorly maintained, or are non-existent. Research indicates that improved protection systems can be designed, but because the bridge owner is responsible for them and monetary assistance is not available, low-cost systems are preferred. Bridge owners, while responsible for maintenance of protection systems, often cannot recover damage costs from the responsible parties, thereby increasing the financial burden.

Summarizing these observations, several actions can be taken as part of a bridge accident reduction strategy. One action would be to expand the Truman-Hobbs Act funding levels to increase the rate of bridge alterations. Policy regarding cost-sharing could be altered to expand the federal share, to prevent a project from being delayed because of owner funding problems. Similarly, the calculation of benefits could be expanded to include aspects now excluded, such as highway traffic improvements. Whenever warranted, bridge closings and reroutings of rail/highway routes may be of greater benefit than the alteration of existing structures. Finally, a new program for upgrading bridge protective systems should have a favorable cost/benefit ratio. Small-scale programs which could improve safety at bridges include application of radar reflectors on bridge piers, additional navigation aids near bridges (especially upstream), and channel improvements in the vicinity of bridges.

3. Locks. Accidents at locks have been found to be strongly associated with downbound passages, reflecting currents and other difficulties in navigating barges into the lock chamber. The most effective method for reducing accidents at locks is to improve the maneuvering conditions for downbound vessels. This suggests such structural improvements as mooring cells, improved guidewalls, elimination of unwarranted structures, improved navigation aids, and structures which can control cross currents.

Although less frequent, upbound accidents occur at locks primarily because of current surge effects below dams. This suggests programs which regulate flow releases at dams to eliminate tricky currents. As with bridges, a

program to improve protection systems at locks, while not eliminating the cause of accidents, can reduce the extent of damages.

Evidence indicates that most lock accidents occur at older, smaller facilities, which suggests that structural upgrading can be justified on the basis of safety issues, although such requirements would most likely remain secondary to traffic needs. Congestion at locks seems to be a contributing factor, which suggests that the two issues are related.

4. Submerged Objects. Situations within this grouping include submerged wrecks, old lock and dam structures, old bridge piers, and shoalings. The legal responsibility for marking and clearing wrecks lies with the vessel owner, but if the owner cannot or will not do so, the Coast Guard can mark it and the Corps can remove the wreck at their discretion (later billing the owner for the costs). A General Accounting Office Study of the Coast Guard's aids to navigation program [39] noted that discretionary marking of wrecks could be expanded beyond the current 15% of 600 inland sunken vessels, but the program was not singled out for criticism.

The National Transportation Safety Board, in its investigation of the collision of the *Dauntless Colocotronis* with a sunken barge near New Orleans, recommended improved standards for defining a navigation hazard, an annual summary of wrecks, and greater clarity in stating depths over submerged objects.[33] With regard to old lock, dam and bridge structures, the problem appears to stem from economy measures in which the entire structure is not removed. This type of calculated risk may ignore the potential costs to vessel operators if the structure is struck.

Shoaling is a more complicated situation because the most common methods of control, dredging and river training, are expensive, thus requiring a balance between costs and benefits. However, carrier interviews and the GAO report [39] pointed out that the Coast Guard does not always maintain navigation aids in the proper position when the channel changes, especially on the Lower Mississippi where channel shifting is most common. In coastal districts, the GAO found that 54% of navigation aids discrepancies were not corrected within 30 days of a

report, while the Second District, which encompasses the inland rivers, had a response time of over 24 weeks in 61% of the cases studied. The Department of Transportation's response to the report indicated that decisions on when to correct discrepancies adequately reflects the situation, and the time of response cannot be inferred as impairing safety. Giving due weight to both opinions, on balance it appears that the Coast Guard has adopted (at least informally) a level of risk component with respect to its navigation aid maintenance program which others may find unacceptable.

One recommendation in the GAO report to which the DOT agreed is the establishment of aids to navigation teams (ANTs), which are units of specially trained personnel equipped with small, high-speed boats capable of responding to discrepancies more quickly and at less cost than buoy tenders. GAO criticized (although DOT disagreed with their conclusions) the utilization of buoy and construction tenders, the management of navigation aids spare parts inventories, funding delays in implementing new projects, and the lack of a formal consultation program with mariners.

Because aids to navigation cannot by themselves prevent accidents but can only suggest conditions, there is no formal procedure for recognizing the cost and benefits associated with their use. Establishment of more formal guidelines based upon risk-assessment principles should be examined for the aids to navigation program. Likewise, a review of the relationship between the Corps and the Coast Guard in providing an adequately maintained and marked channel may be warranted.

(c) Alteration of Operating Procedures

1. Rules of the Road. Basic navigation procedures are established by law and regulation in "rules of the road". The United States has adopted as a treaty the 1972 International Regulations for Preventing Collisions at Sea (COLREG) established by the United Nation's Intergovernmental Maritime Consultative Organization (IMCO), which became effective in 1977. These rules apply

on the high seas and as close to the shore as practical, in most cases at the outer jetty or entrance light of a channel.

Inland rules of the road generally apply inward of the COLREG demarcation line which defines the limit of the International Rules. The Western Rivers Rules apply on all inland waters above the Huey P. Long Bridge at Mile 106.4 on the Lower Mississippi River and on the Atchafalaya River above Mile 115, where it joins the Morgan City-Port Allen Alternate Route. Great Lakes Rules apply on the Great Lakes, the St. Lawrence Seaway, the Chicago River above the Ashland Avenue bridge in Chicago, and above the O'Brien lock on the Calumet River. Unification of all inland rules, to include changes which would conform to International Rules, has been signed into law (Public Law 96-591) as of December 24, 1980.

In offshore approaches to harbor channels, safety fairways can be designated by the United States Coast Guard. Within the fairways, no permanent structures (other than aids to navigation) may be erected. Safety fairways are commonly used to segregate shipping lanes from offshore drilling and production platforms.

2. Radio. On January 1, 1973, the Bridge-to-Bridge Radio-Telephone Act regulations became effective. Their purpose was to require all larger vessels to have a radiotelephone available so that vessels could communicate with each other. The regulations also suggest (but do not require) that broadcast calls be made in blind situations, such as when approaching a bend or intersection.

This regulation has been credited with preventing about 80% of the collisions which occur between moving vessels, in cases when communication could prevent an accident. Furthermore, a study for the United States Coast Guard [40] indicates that 30% of all collisions, groundings, and rammings have been reduced by this regulation. Changing the regulation to require broadcast calls in blind situations may be required to improve the effectiveness of the system.

3. Vessel Traffic Management. Traffic management takes two forms. Passive management, one form, affects all waterways in some way. It includes such things as rules of the nautical road, traffic separation

schemes (TSS), and speed control. Such measures are intended to solve general problems of nationwide interest or to order traffic in a very specific way to suit a limited area. Passive measures are normally implemented by regulations or even international convention.

The active form of traffic management is the Vessel Traffic Service (VTS). Table IV-6 indicates the location of United States VTSs. These systems require participation by regulation in some areas and are voluntary in others. Each is designed specifically for the waterway it serves and the special problems involved. Like passive measures, these VTSs seek to reduce collisions, rammings, and groundings. Unlike passive measures, the nature of problems in the specific area served by a VTS require active attention, such as monitoring traffic near blind bends (the lower Mississippi River for example) or traffic scheduling (for one-way traffic on the St. Marys River, for example).

The design of a specific VTS addresses four major component requirements. In all cases a VTS must be able to communicate with the vessel population of interest, but the specific characteristics determine the radio frequencies and the number of frequencies to be used. A second component requirement is for surveillance/monitoring of the vessel population. Depending on the geography and the need for accuracy, the specific requirements and the associated hardware varies widely. A third component includes normally passive measures such as TSSs or speed limits which can be actively monitored from the VTS. Finally, there is the management of information gathered. This component is the service to the mariner or the VTS product. Providing timely information to the mariner about his traffic environment so that he can avoid collisions, rammings, and groundings is preferred to dictating schedules or maneuvers. Information management ranges from simple manual plotting to complex computer processing, again dependent upon local characteristics.

Table IV-6

Operating and Planned Vessel Traffic Services

Location	Equipment	Status
New York Harbor	Computerized VMRS	Operational in 1982
	2 Surveillance radar sites	Operational in 1982
	6 LLTV sites	Operational in 1982
New Orleans	Computerized VMRS	Operational
	1 Surveillance radar site	Planned 1982
	3 LLTV sites	Planned 1981
Houston Galveston	Computerized VMRS	Operational
	1 Surveillance radar site	Operational
	4 LLTV sites	Operational
	3 LLTV sites	Planned 1981
San Francisco	2 Surveillance radar sites	Operational
Seattle Puget Sound	4 Surveillance radar sites (1)	Operational
	[illegible] Surveillance radar sites	Planned 1980
Valdez, Alaska	2 Surveillance radar sites	Operational
	LORAN-C position reporting system	Planned 1982-1984
Louisville, Kentucky	VHF Movement Reporting System	Operational during high water only
Berwick Bay, Louisiana	VHF Movement Reporting System	Operational
	1 LLTV site	Planned 1981
St. Mary's River Soo Locks	VHF Movement Reporting System	Operational
	1 LLTV site	Operational

LLTV = Low-light level television.
VMRS = Vessel movement reporting system.

Note: (1) One site to be disestablished in 1980.

Source: U.S. Coast Guard.

The Coast Guard is planning to upgrade all surveillance radar VTS sites to computer-assisted tracking and graphics displays in 1985 through 1990. An algorithm which evaluates four categories of expected benefits (vessel and cargo damages, property damages, pollution incidents, deaths and injuries) is used to establish a cost/benefit analysis for each level of VTS.[41] Operating costs for passive VTS are under $100,000 annually, whereas active systems cost from $500,000 to over $1 million annually, depending upon design.[40]

Although there has been some discontent expressed with the New Orleans VTS, it appears that most concern centers around communications problems which are being corrected by the alteration of assigned channel frequencies and monitoring requirements. An issue not yet clearly resolved is whether VTS should be advisory or mandatory, since experience has shown a low rate of participation in voluntary systems by foreign vessels.

4. <u>Navigation Position Systems</u>. Navigation position reference systems at present consist of aids to navigation (buoys, daymarks, channel markers, reference lights, and lighthouses), navigation charts, shipboard radar, and the LORAN-C system in ocean areas and the Great Lakes. Advances in satellite communications systems, inertial guidance devices, and other electronics technology in aircraft navigation systems have the potential of being adapted to the marine environment. Primary navigation needs are increases in positional accuracy so that coverage can be extended into inland waters, an ability to cope with environmental problems (rain, fog, storms), and reasonable cost to maximize the number of vessels which can utilize the system.

Section 507 of Public Law Number 95-564, which amended the Communications Satellite Act of 1962 to provide for United States participation in the International Maritime Satellite Organization (INMARSAT), directed a study of all government radio navigation systems to determine the most effective manner of reducing the proliferation and overlap of such systems. The study is currently being conducted by the Office of Management and Budget and the Office of Telecommunications Policy of the Department of Commerce.

The study will recommend a Federal Radio Navigation Plan which will coordinate civilian and military

uses and recommend a plan to expand the usefulness of such sytems as OMEGA, LORAN, and NAVSTAR. Similarly, the American Waterways Operators have suggested a feasibility study be made of developing an automated digital microwave system on inland waters to overcome limitations in the current VHF-FM voice communications system. The system would eventually provide for voice, facsimile, data transfer and radio printer, in addition to its linkage between vessels and landline telephones.

(d) Improvements to Vessels and Their Equipment

Equipment failures are a notable cause of all types of vessel casualties. The National Transportation Safety Board has proposed new standards for improvements to vessel steering gears and backup engine-order communications systems.[33] Rules have not yet been proposed, although such regulations are currently under study. The intent of improving vessel steering is to reduce collisions, rammings and groundings, and secondarily to limit pollution incidents resulting from such casualties. At present, the contemplated rules would apply only to tankers of at least 10,000 tons, but the NTSB believes they should cover all vessels of 1,600 tons or more. Similarly, failures of barge lashings and hawsers are a significant contributing factor in accidents, which suggests the need for new and improved designs.

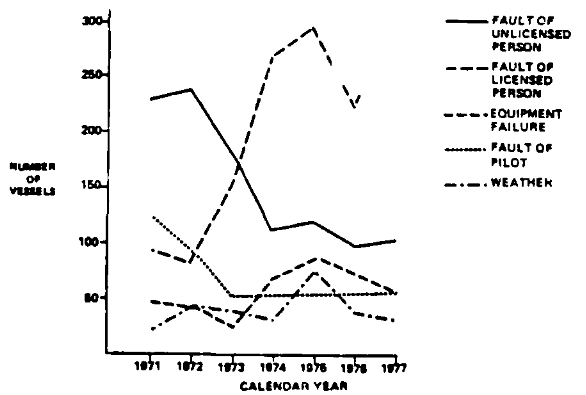
Another area in which vessel design can affect accidents is fires and explosions. Concern over accidents involving hazardous materials has prompted the extensive safety standards incorporated in 33 CFR, Subchapters D and O. Trends are for expanded applications of fire suppression equipment, and implementation of new design and construction techniques as technology develops. This topic is covered in more detail in Section V.

A topic which warrants investigation is the relationships between towboat horsepower, tow configuration, and vessel response characteristics. Such a study could be part of a broader study of vessel response characteristics. Related to this topic is the development and installation on vessels of improved depth measuring equipment, rate of turn indicators, collision avoidance systems, and current measuring devices. Backup radars may be extended to smaller vessels.

GRAPH SERIES 1: CASUALTY CAUSE BY CALENDAR YEAR FOR FIVE TYPES OF CASUALTY

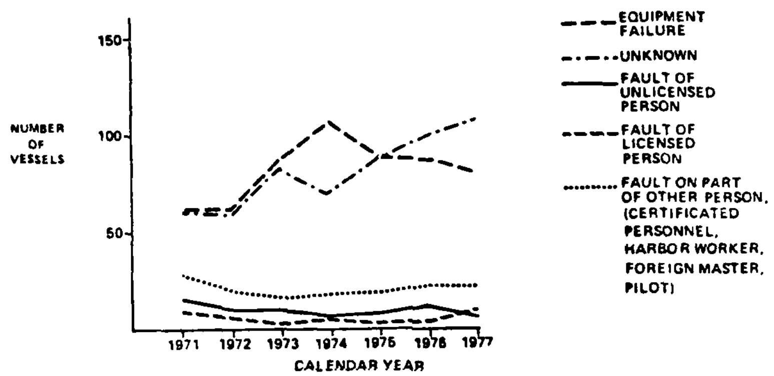
TYPES:	COLLISIONS FIRES/EXPLOSIONS GROUNDINGS MATERIAL FAILURES RAMMINGS
CAUSES	FIVE MOST FREQUENTLY INVOLVED FOR EACH CASUALTY TYPE

GRAPH IA: COLLISIONS

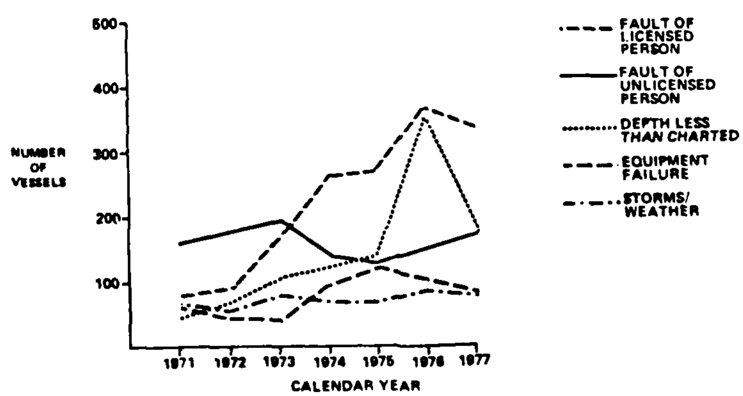


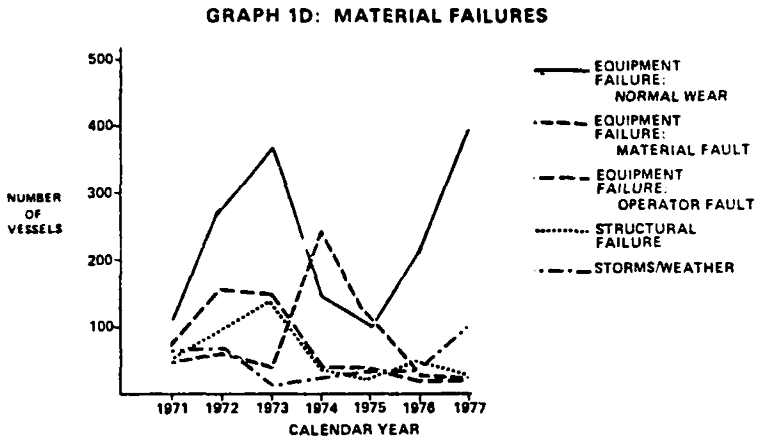
SOURCE: United States Coast Guard Marine Safety Statistical Review - 1979.

GRAPH 1B: FIRES/EXPLOSIONS



GRAPH 1C: GROUNDINGS




GRAPH 1D: MATERIAL FAILURES
500
400
300
200
100
NUMBER OF VESSELS
1971 1972 1973 1974 1975 1976 1977
CALENDAR YEAR
EQUIPMENT FAILURE: NORMAL WEAR
EQUIPMENT FAILURE: MATERIAL FAULT
EQUIPMENT FAILURE: OPERATOR FAULT
STRUCTURAL FAILURE
STORMS/WEATHER

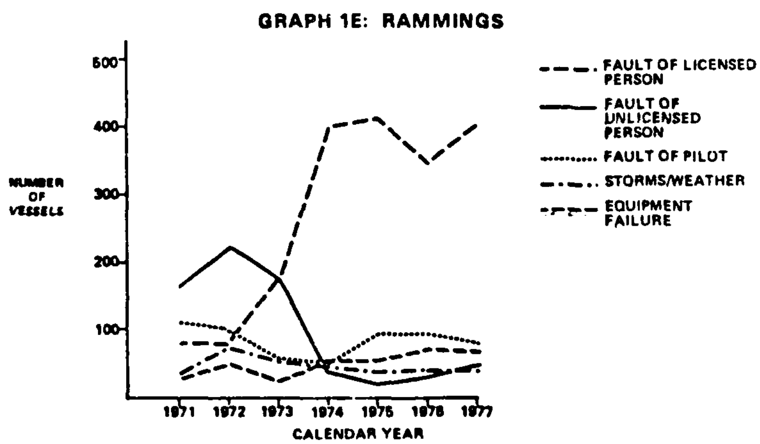

GRAPH 1E: RAMMINGS
500
400
300
200
100
NUMBER OF VESSELS
1971 1972 1973 1974 1975 1976 1977
CALENDAR YEAR
FAULT OF LICENSED PERSON
FAULT OF UNLICENSED PERSON
FAULT OF PILOT
STORMS/WEATHER
EQUIPMENT FAILURE

EXHIBIT IV-2
Page 1 of 3

NUMBER OF ACCIDENTS/NUMBER OF VESSELS INVOLVED FOR SELECTED TYPES OF CASUALTIES BY WATERWAYS SEGMENT (FISCAL YEARS 1977 AND 1978)

	Collisions				Rammings		Groundings		
Waterways Segment	Moving Vessels	Docking or Undocking	Floating or Submerged Object	Other	Bridge, Lock or Dam	Other	With Vessel Damage	Without Vessel Damage	Fire and/or Explosions of Cargo
Mississippi River above Cairo, IL (Including St. Croix River)	20/69	2/7	11/35	3/10	43/136	73/91	61/169	93/249	[illegible]
Mississippi River, New Orleans, LA to Cairo, IL (Including Yazoo River)	44/184	1/4	12/24	5/6	18/109	37/103	60/231	[illegible]	[illegible]
Mississippi River, New Orleans, LA to Gulf (Including Mississippi River - Gulf Outlet, Coastal Areas)	51/167	8/23	14/18	22/41	16/32	84/154	40/63	[illegible]	6/6
Illinois Waterway (Including Inland Rules Sections of Chicago and Calumet Rivers)	16/55	1/3	5/8	5/8	54/112	22/53	20/43	10/14	-
Missouri River	-	-	-	-	1/2	3/7	6/14	2/2	
Ohio River	13/42	-	12/21	6/15	60/140	16/33	[illegible]	51/137	
Monongahela River	1/3	-	1/2	-	2/4	1/3	1/2		
Allegheny River	-	-	-	-	-	-	-		
Kanawha River	-	-	2/4	-	2/4	2/5	-	-	
Kentucky River	-	-	-	-	-		-		
Green River	1/3	-	1/2	-	-	1/3	-		
Cumberland River	-	-	-		2/4	-	2/5	2/7	
Tennessee River	-	-	8/13	-	19/56	4/10	9/19	9/19	
Arkansas and White Rivers	1/3	-	2/3		[illegible]	7/15	2/5	5/17	
Ouachita, Black and Red Rivers	-	-	-	-		-	1/3		
Atchafalaya and Old Rivers (above Morgan City, LA)	2/5	-	-	-	2/4		1/3	1/1	
Morgan City - Port Allen Routes	3/10	1/2	1/2	-	9/26	[illegible]		1/2	
Gulf Intracoastal Waterway - West (Including Harvey and Algiers Canals)	[illegible]	1/3	9/22	2/8	[illegible]	38/105	22/44	[illegible]	1/1
Louisiana Gulf Coast Area (Including Barataria Bay Waterway, Bayou Teche, Houma Navigation Canal, Mermentau River, Calcasieu River, Vermilion River)	18/40	1/2	[illegible]	15/26	[illegible]	[illegible]	[illegible]	4/4	

NUMBER OF ACCIDENTS/NUMBER OF VESSELS INVOLVED FOR SELECTED TYPES OF CASUALTIES BY WATERWAYS SEGMENT (FISCAL YEARS 1977 AND 1978)

	Collisions				Rammings		Groundings		Fires
Waterways Segment	Moving Vessels	Docking or Undocking	Floating or Submerged Object	Other	Bridge, Lock or Dam	Other	With Vessel Damage	Without Vessel Damage	and/or Explosions of Cargo
Neches and Sabine Rivers (Including Sabine Pass)	20/72	3/8	8/11	4/10	4/7	22/56	16/27	11/19	1/1
Houston Ship Channel	35/99	18/48	19/23	9/19	7/13	73/161	25/44	38/56	1/1
Texas Gulf Coast	17/42	4/11	6/8	5/9	4/13	49/109	31/41	13/17	1/1
Gulf Intracoastal Waterway - East (Including Inner Harbor Navigation Canal)	8/28	1/3	1/2	-	18/41	9/10	12/29	5/8	-
Alabama/Mississippi Coast	6/16	2/10	1/1	7/14	5/10	11/25	7/8	7/14	1/1
Black Warrior - Tombigbee Waterway	7/24	-	1/2	-	9/24	2/3	5/10	-	-
Alabama and Coosa Rivers	-	-	-	-	-	-	-	-	-
North Florida Gulf Coast	-	-	-	-	1/2	4/7	2/3	5/5	-
Appalachicola, Flint and Chattahoochee Rivers	-	-	-	-	-	-	-	-	-
West Florida Gulf Coast	13/27	3/9	7/9	2/4	2/4	18/43	26/47	53/80	-
Georgia/Florida Atlantic Coast (Including Key West)	13/34	1/3	5/7	2/4	7/18	42/68	30/42	26/42	1/1
Carolinas Coast	5/12	-	4/4	3/7	3/7	17/35	35/54	134/207	-
Hampton Roads Area	4/12	6/21	4/4	7/15	11/23	20/47	9/12	21/28	-
Baltimore Harbor Area	5/14	1/2	3/3	1/4	3/5	17/37	2/2	13/25	-
Other Chesapeake Bay	10/33	1/2	4/4	2/13	5/14	13/21	8/14	28/50	-
Delmarva Coast	-	-	4/5	1/2	-	1/1	10/10	30/30	-
Philadelphia Harbor Area	2/5	5/15	-	8/20	1/5	14/66	12/19	42/55	1/1
Other Delaware Bay	3/7	-	-	1/1	-	1/2	-	15/19	1/1
New York Harbor	19/57	8/24	12/17	12/27	8/16	51/109	32/57	27/18	-
New Jersey and Long Island Area	10/24	6/17	4/8	6/11	9/19	18/45	18/26	15/25	-

NUMBER OF ACCIDENTS/NUMBER OF VESSELS INVOLVED FOR SELECTED TYPES OF CASUALTIES BY WATERWAYS SEGMENT (FISCAL YEARS 1977 AND 1978)

	Collisions				Rammings		Groundings		Fires
Waterways Segment	Moving Vessels	Docking or Undocking	Floating or Submerged Object	Other	Bridge, Lock or Dam	Other	With Vessel Damage	Without Vessel Damage	and/or Explosions of Cargo
New England Coast	18/39	4/12	7/8	10/18	11/21	27/47	40/44	50/61	4/5
Hudson River and New York State Canal System	-	2/6	1/2	2/3	4/9	8/11	9/15	9/13	-
Lake Ontario and St. Lawrence Seaway	-	1/2	-	-	6/6	-	11/13	7/9	-
Lake Erie, Detroit River and St. Clair River	5/12	2/4	5/5	8/13	11/18	32/35	3/4	26/26	-
Lake Huron, Straits of Mackinac and St. Mary's River (Soo Locks)	2/4	1/2	4/4	1/1	10/10	24/28	13/14	23/23	-
Lake Michigan (Including Calumet and Chicago Rivers)	3/5	1/2	9/11	4/4	6/7	19/25	7/8	9/11	-
Lake Superior	1/2	-	-	-	3/4	7/9	4/4	3/4	-
Puget Sound and Straits of San Juan de Fuca	9/17	1/2	4/8	3/9	6/16	32/58	14/14	9/11	1/1
Columbia and Willamette Rivers	11/22	1/2	7/7	3/7	2/3	21/37	12/16	32/37	-
Oregon/Washington Coast	10/20	-	18/21	2/9	-	9/12	25/30	58/58	-
North California Coast	4/8	1/3	5/6	-	-	4/6	8/8	22/22	-
San Francisco Bay (Including Channels to Sacramento and Stockton)	9/18	4/12	2/2	2/6	2/2	45/75	13/13	36/42	-
Los Angeles-Long Beach Harbor Area	10/23	7/14	2/2	2/4	-	18/34	8/8	1/1	1/1
South California Coast	11/23	8/16	4/4	3/7	-	12/27	16/16	9/9	-
Southeast Alaska Coast	9/17	2/4	4/4	10/20	-	18/24	34/35	19/19	-
South Central Alaska Coast	2/4	2/4	3/3	1/2	-	11/15	27/33	5/5	-
West and North Alaska Coasts	-	1/2	1/1	1/1	-	1/1	8/12	2/2	-
Hawaiian Islands	2/4	2/4	-	5/11	1/1	6/9	11/12	1/1	-
Puerto Rico	1/1	-	4/4	2/7	-	32/66	11/16	12/14	-

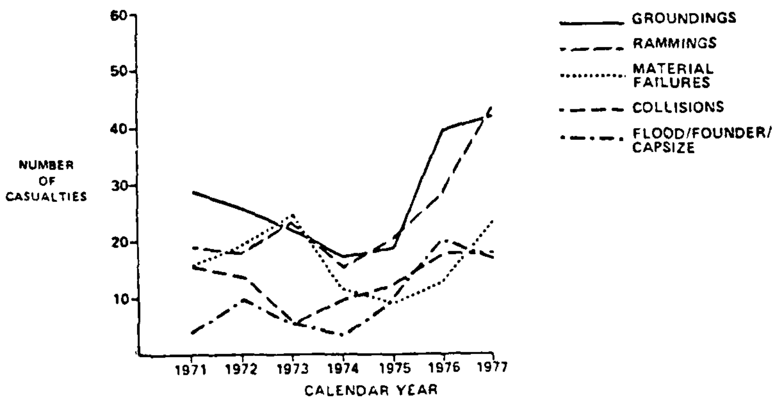
Source: A. T. Kearney analysis of U.S. Coast Guard Vessel Casualty Data (with corrections for known errors).

GRAPH SERIES 3: TYPE OF CASUALTY BY CALENDAR YEAR FOR SEVEN PORT AREAS

AREAS: NEW YORK CITY/LONG ISLAND
DELAWARE BAY
CHESAPEAKE BAY
NEW ORLEANS/PASSES OF THE MISSISSIPPI RIVER
HOUSTON/GALVESTON/PORT ARTHUR
LOS ANGELES/LONG BEACH
PUGET SOUND

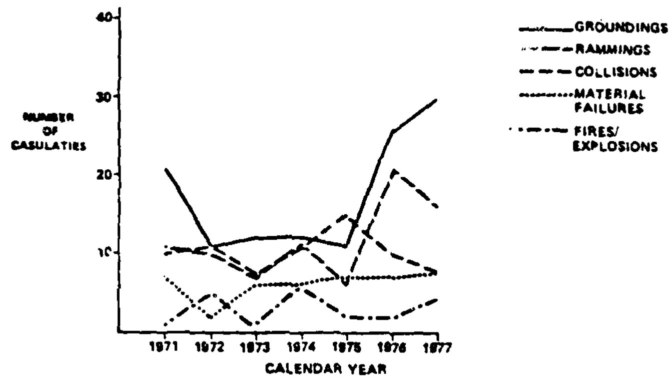
CASUALTY TYPES: FIVE MOST FREQUENT IN EACH AREA

GRAPH 3A: CHESAPEAKE BAY

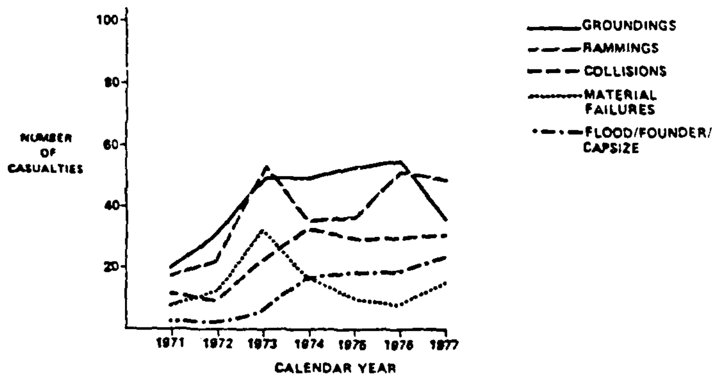


SOURCE: United States Coast Guard Marine Safety Statistical Review - 1979.

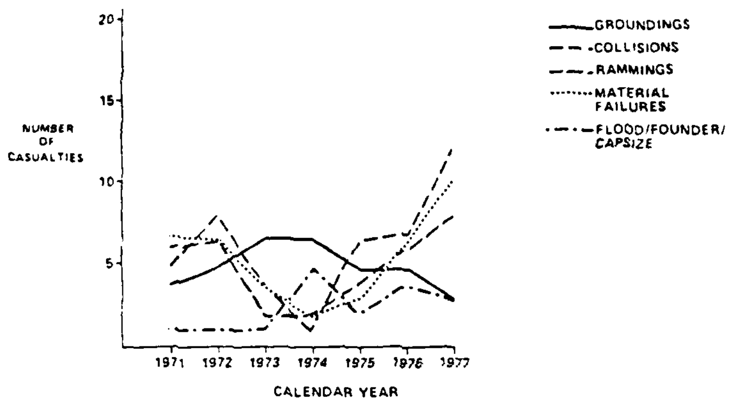
GRAPH 3B: DELAWARE BAY



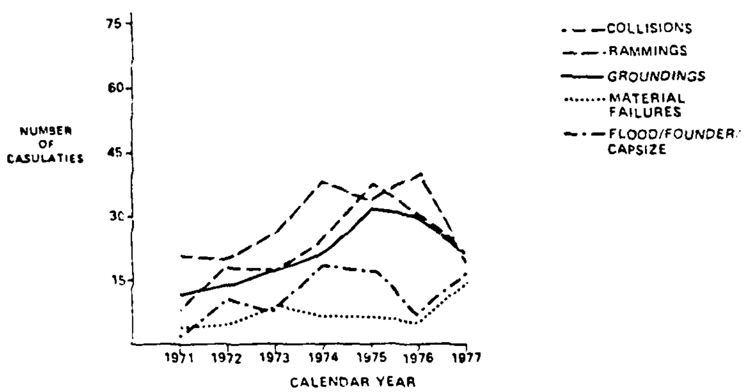
GRAPH 3C: HOUSTON/GALVESTON/PORT ARTHUR



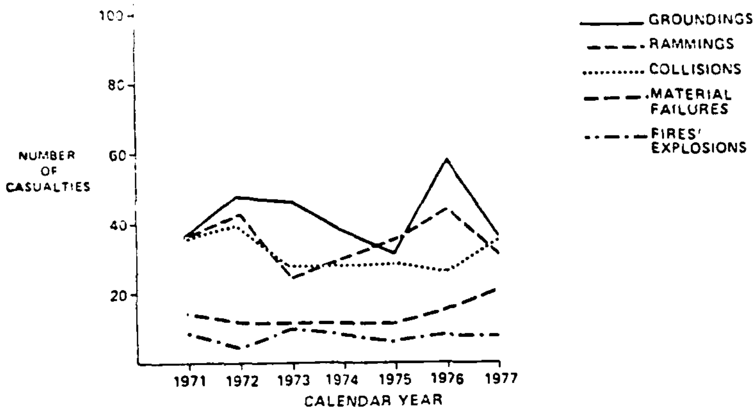
GRAPH 3D: LOS ANGELES/LONG BEACH



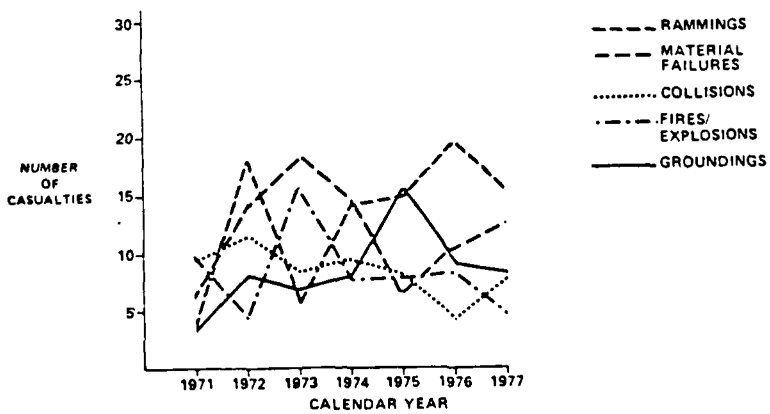
GRAPH 3E: NEW ORLEANS/MISSISSIPPI RIVER PASSES



GRAPH 3F: NEW YORK/LONG ISLAND



GRAPH 3G: PUGET SOUND



VESSEL CASUALTIES

PRIMARY CAUSE BY TYPE OF CASUALTY

FOR PRIMARY (INITIATING) VESSELS ONLY

FISCAL YEARS 1977-1978

	Primary Cause	1 Collision - Vessels Meeting	2 Collision - Vessels Crossing	3 Collision - Vessels Overtaking	4 Ramming - Vessel Anchored or Moored	5 Collision - Docking or Undocking	6 Collision - Fog	7 Collision - Not Otherwise Classified
A.	Personnel Fault - State Pilot	21	2	6	15	10	-	1
B.	P.F. - Federal Pilot	6	-	1	3	3	-	2
C.	P.F. - Foreign Pilot or Master	20	2	4	21	16	-	8
D.	P.F. - Licensed Personnel	232	15	30	157	66	2	56
E.	P.F. - Certified Personnel	-	1	1	-	-	-	-
F.	P.F. - Unlicensed Personnel	118	10	10	48	11	1	9
G.	P.F. - Unlicensed Pleasure Boat	2	-	-	-	-	-	-
H.	P.F. - All Others	1	-	-	1	1	-	3
I.	Calculated Risk	1	-	-	-	-	-	-
J.	Storms, Heavy Weather	2	-	-	2	-	-	5
K.	Adverse Weather	7	-	-	12	4	-	15
L.	Unusual Currents	2	-	-	2	-	-	3
M.	Sheer, Suction, Bank Cushion	15	1	4	2	-	-	-
N.	Depth Less than Charted	1	-	-	3	1	-	[illegible]
O.	Restricted Maneuvering Room	1	-	-	4	-	-	1
P.	Structural Failure	-	-	-	1	-	-	2
Q.	Equipment Failure - Normal Wear	28	-	3	27	24	-	18
R.	E.F. - Material Fault	1	-	-	1	3	-	-
S.	E.F. - Design	-	-	-	-	-	-	-
T.	E.F. - P.F. of Operating Personnel	1	-	-	1	2	-	1
U.	Unseaworthy	1	-	-	-	-	-	-
V.	Unknown/Other	18	-	2	20	2	-	11
W.	Fault of Other Vessel/Person	3	-	-	4	1	1	2
X.	Improper Maintenance	-	-	-	-	-	-	-
Y.	Floating Debris, Submerged Object	1	-	-	-	-	-	-
Z.	Insufficient HP/Inadequate Tugs	2	-	-	1	2	-	2
	Total	486	31	61	325	146	4	140

VESSEL CASUALTIES

PRIMARY CAUSE BY TYPE OF CASUALTY

FOR PRIMARY (INITIATING) VESSELS ONLY

FISCAL YEARS 1977-1978

Primary Cause	8 Collision - Floating or Submerged Object	9 Ramming - Fixed Object	10 Collision - Ice	11 Ramming - Navigation Aid	12 Collision - Other Than With Vessel
A. Personnel Fault - State Pilot	3	52	-	3	-
B. P.F. - Federal Pilot	-	34	-	-	-
C. P.F. - Foreign Pilot or Master	1	57	-	6	-
D. P.F. - Licensed Personnel	48	642	1	83	18
E. P.F. - Certified Personnel	-	-	-	1	-
F. P.F. - Unlicensed Personnel	22	46	1	16	11
G. P.F. - Unlicensed Pleasure Boat	-	-	-	-	-
H. P.F. - All Others	1	8	-	1	-
I. Calculated Risk	-	-	2	-	1
J. Storms, Heavy Weather	-	12	1	2	3
K. Adverse Weather	3	32	14	5	4
L. Unusual Currents	1	13	-	-	1
M. Sheer, Suction, Bank Cushion	1	7	-	-	1
N. Depth Less than Charted	9	3	-	1	-
O. Restricted Maneuvering Room	4	10	-	-	1
P. Structural Failure	-	8	-	1	-
Q. Equipment Failure - Normal Wear	2	100	-	8	4
R. E.F. - Material Fault	-	-	-	-	-
S. E.F. - Design	-	2	-	-	-
T. E.F. - P.F. of Operating Personnel	-	3	-	2	-
U. Unseaworthy	-	-	-	-	-
V. Unknown/Other	8	18	-	14	3
W. Fault of Other Vessel/Person	2	25	-	1	2
X. Improper Maintenance	1	3	-	-	-
Y. Floating Debris, Submerged Object	168	22	-	-	-
Z. Insufficient HP/Inadequate Tugs	-	14	-	1	-
Total	274	1,111	19	145	49

VESSEL CASUALTIES

PRIMARY CAUSE BY TYPE OF CASUALTY

FOR PRIMARY (INITIATING) VESSELS ONLY

FISCAL YEARS 1977-1978

	Primary Cause	11 Explosion/Fire Liquid Bulk Cargo	14 Explosion/Fire General Cargo	15 Explosion/Fire Vessel Fuel	16 Fire - Vessel Structure	17 Fire - Vessel Equipment	18 Explosion - Boiler	19 Explosion - Pressurized Gas	20 Explosion/Fire Not Otherwise Classified	21 Grounding With Vessel Damage	22 Grounding Without Damage
A.	Personnel Fault - State Pilot	-	-	-	-	-	-	-	-	15	65
B.	P.F. - Federal Pilot	-	-	-	-	-	1	-	-	9	25
C.	P.F. - Foreign Pilot or Master	1	-	-	1	-	-	-	-	18	72
D.	P.F. - Licensed Personnel	-	2	1	4	-	1	-	-	108	198
E.	P.F. - Certified Personnel	-	1	-	1	1	-	-	-	3	1
F.	P.F. - Unlicensed Personnel	-	-	1	8	3	1	-	2	155	176
G.	P.F. - Unlicensed Pleasure Boat	-	-	-	-	-	-	-	-	5	1
H.	P.F. - All Others	2	7	-	16	3	-	1	2	3	1
I.	Calculated Risk	-	-	-	-	-	-	-	-	6	4
J.	Storms, Heavy Weather	-	-	-	1	-	-	-	-	32	22
K.	Adverse Weather	-	-	-	-	-	-	-	-	34	48
L.	Unusual Currents	-	-	-	-	-	-	-	-	7	6
M.	Shear, Suction, Bank Cushion	-	-	-	-	-	-	-	-	9	9
N.	Depth Less than Charted	-		-	-	-	-	-	-	93	279
O.	Restricted Maneuvering Room	-	-	-	-	-	-	-	-	6	4
P.	Structural Failure	-	-	1	1	-	-	-	-	7	4
Q.	Equipment Failure - Normal Wear	4	2	4	56	49	10	1	9	68	76
R.	E.F. - Material Fault	-	-	-	5	1	-	-	-	2	1
S.	E.F. - Design	-	-	-	3	1	-	-	-	-	-
T.	E.F. - P.F. of Operating Personnel	1	1	-	2	1	2	-	2	2	6
U.	Unseaworthy	-	-	-	-	-	-	-	-	3	3
V.	Unknown/Other	-	3	12	148	27	3	2	11	38	20
W.	Fault of Other Vessel/Person	-	-	-	-	-	-	-	-	9	11
X.	Improper Maintenance	-		-	-	1	-	-	-	1	-
Y.	Floating Debris, Submerged Object	-	-	-	-	-	-	-	-	17	4
Z.	Insufficient HP/Inadequate Tugs	-	-	-	-	-	-	-	-	1	5
	Total	8	16	19	246	87	18	4	26	845	1,249

VESSEL CASUALTIES

PRIMARY CAUSE BY TYPE OF CASUALTY

FOR PRIMARY (INITIATING) VESSELS ONLY

FISCAL YEARS 1977-1978

	23	24	25	26	27	28	29	30	31	32
Primary Cause	Foundering	Capsizing	Flooding	Weather Damage	Cargo Damage	Material Fault - Vessel Structure	Material Fault - Vessel Machinery	Material Fault - Other	Other Casualties	Barge Breakaway
A. Personnel Fault - State Pilot	1	-	1	-	-	1	-	-	7	
B. P.F. - Federal Pilot		-	-	-	-			-	-	
C. P.F. - Foreign Pilot or Master	1	-	1	-	-	2		-	4	-
D. P.F. - Licensed Personnel	51	12	8	2	1	7	7	12	24	10
E. P.F. - Certified Personnel	-	-	-	-	-	-	-	1	1	-
F. P.F. - Unlicensed Personnel	62	17	24	3	-	4	4	6	12	5
G. P.F. - Unlicensed Pleasure Boat	-	2	-	-	-	-	-	-		-
H. P.F. - All Others	15	3	1	-	7	7	5	9	11	7
I. Calculated Risk	-	1	-	-		-		-	2	
J. Storms, Heavy Weather	52	33	26	18	25	69	3	19	8	1
K. Adverse Weather	44	15	8	3	5	43	3	22	9	6
L. Unusual Currents	9	2	-	-	-	-	-	1	4	-
M. Sheer, Suction, Bank Cushion	-	-	-	-	-	-	-	-	2	-
N. Depth Less than Charted	3		-	-	-	-	-	-		-
O. Restricted Maneuvering Room	1	-	-	-	-	-	3	-	1	-
P. Structural Failure	57	2	14	-	-	46	[illegible]	5	3	-
Q. Equipment Failure - Normal Wear	64	10	44	1	1	10	717	127	12	5
R. F.F. - Material Fault	1	-	1	-		1	18	11	-	-
S. F.F. - Design	-	-	1	-	-	6	18	2	-	-
T. F.F. - P.F. of Operating Personnel	9	-	9	-	-	4	32	26		-
U. Unseaworthy	107	9	14	1	-	23	2	-	-	1
V. Unknown/Other	112	18	9	-	-	16	21	6	11	5
W. Fault of Other Vessel/Person	2		1	-	-	1	1	-	1	-
X. Improper Maintenance	23		12	-	-	7	3	1	-	-
Y. Floating Debris, Submerged Object	11	1	9	-	-	2	3	8	2	-
Z. Insufficient HP/Inadequate Tugs	-		-	-	-	-	-	-	-	-
Total	649	105	181	28	39	251	856	246	136	40

Source: U.S. Coast Guard Casualty Records, 1977 and 1978.

V - HAZARDOUS MATERIALS ISSUES

Transportation of hazardous materials has become a major safety concern because of the perception that the incidence and severity of accidents involving such materials have been increasing. Concern has not been focused solely upon the waterways industry; rail tank car safety has received perhaps more attention.

This section discusses the types of commodities defined as hazardous, reviews existing and proposed regulations, and examines the risks and problems associated with water transportation of hazardous materials. The key finding is that the issue of hazardous materials transport safety is the predominant aspect of overall waterways system safety, since the presence of hazardous materials is the major element of risk.

TYPES OF HAZARDOUS MATERIALS

(a) Department of Transportation

The Department of Transportation has listed in 49 CFR Section 172.101 those materials designated as hazardous materials for purposes of transportation. Part 172 also prescribes the requirements for shipping papers, package marking, labeling, and transport vehicle placarding applicable to the shipment and transportation of those hazardous materials. Over 1,600 items are listed in the Hazardous Materials Table. Classes have been defined for hazardous materials, with the general descriptions noted on Figure V-A.

Although hazardous materials are commonly identified with chemicals, the types of materials encompassed in 49 CFR Subchapter C are much broader. The range is from small arms ammunition to nitric acid, and from liquid carbon dioxide to charcoal briquets. Many hazardous materials are indispensible to modern society. Chlorine, a potentially deadly substance, is a vital component in the manufacture of plastics and paper, and is also used to

purify drinking water. Ammonia, dangerous if breathed in concentrations greater than 25 parts per million of air, is widely used in the manufacture of fertilizers. Natural and petroleum gases, cryogenically liquified for transport, provide energy to homes, farms, and businesses throughout the U.S.[42]

Figure V-A

DOT Hazardous Materials Classes

Figure V-A

DOT Hazardous Materials Classes

Flammable Liquid - Any liquid having a flash point below 100°F.

Combustible Liquid - Any liquid having a flash point at or above 100°F. and below 200°F.

Pyrophoric Liquid - Any liquid that ignites spontaneously in dry or moist air at or below 130°F.

Explosive, Class A - Any explosive material or device which can be detonated by a blasting cap, spark, flame, or impact.

Explosive, Class B - Those explosives which function by rapid combustion rather than detonation.

Explosive, Class C - Certain manufactured articles which contain restricted amounts of explosive material, and certain fireworks.

Flammable Solid - Any solid material, except an explosive, which is liable to cause fires through friction, retained heat from manufacturing or processing, or which can be ignited readily to burn vigorously and persistently.

Oxidizer - A substance that yields oxygen readily to stimulate the combustion of organic matter.

Organic Peroxide - An organic compound containing the bivalent -O-O- structure.

Corrosive Material - A liquid or solid that on contact damages human skin tissue, or a liquid that has a severe corrosion rate on steel.

Compressed Gas - Any material or mixture contained at an absolute pressure exceeding 40 psi at 70°F., or having an absolute pressure exceeding 104 psi at 130°F., or any liquid flammable material having a vapor pressure exceeding 40 psi absolute at 100°F.

Flammable Gas - Any compressed gas found to be flammable.

Poison A - Extremely dangerous gases or liquids whose vapors when mixed with air are dangerous to life.

Poison B - Liquids or solids known to be toxic to humans.

Etiologic Agent - A viable microorganism or its toxin which causes human disease.

Radioactive Material - Any material which spontaneously emits ionizing radiation.

Irritating Material - A liquid or solid which upon contact with fire or when exposed to air gives off dangerous or intensely irritating fumes.

Other Regulated Material-A - A material which has an anesthetic, irritating, noxious, toxic, or similar property which can cause extreme annoyance or discomfort to humans.

Other Regulated Material-B - A material capable of causing significant damage to a transport vehicle from leakage.

Other Regulated Material-C - A material which exhibits inherent characteristics which make it unsuitable for transport unless properly identified and prepared for shipment.

Other Regulated Material-D - A material which presents a limited hazard during transport.

Source: 49 CFR Part 173.

(b) Environmental Protection Agency

The responsibility for regulating the shipment of hazardous materials in packaged form, and implementation of penalty actions against those responsible for hazardous materials marine pollution, is shared by the Coast Guard, the DOT's Material Transportation Bureau, and the Environmental Protection Agency. This authority is mandated in the Hazardous Materials Transport Act of 1974 and the Federal Water Pollution Control Act of 1972.

On March 13, 1978, the EPA published regulations in the Federal Register designating 271 substances as hazardous to the marine environment. Of these, only 10 had properties sufficiently like oil to allow their removal from the marine environment. Under authority of the Clean Water Act of 1977, the EPA Administrator was authorized to assess penalties against a vessel or barge owner on a "strict liability" (regardless of fault) basis for the discharge of nonremovable substances.

Private industry reaction was swift. In the United States District Court for the Western District of Louisiana, the Manufacturing Chemists Association (now Chemical Manufacturers Association) filed suit for injunctive relief against the EPA rules. On August 4, 1978, District Judge Earl E. Vernon permanently enjoined EPA from implementation of the rules, terming them without merit, void, and "arbitrary" with regards to designations of both substances and harmful quantities. Coparties in the suit were the American Waterways Operators, Inc., the Association of American Railroads, and the American Petroleum Institute.[42]

On August 29, 1979, the EPA published a revised list of substances considered hazardous to the marine environment. The regulations eliminate the distinctions between what is removable and what is not removable, eliminate separate penalty rates for different substances, require the EPA to determine only those quantities of each substance which may be harmful to the environment, establish a $50,000 penalty which can be assessed by the EPA for

hazardous substances discharges, and include a provision to increase that penalty to $250,000 in the case of a knowing and willful discharge. The Coast Guard can assess a civil penalty of up to $5,000 per discharge if the EPA does not act. These penalties are separate from those applicable to oil spills.[43]

(c) Hazardous Wastes

A trend noted in the NWS Corps field interviews was an increase in the movement of hazardous wastes by water to specialized disposal facilities. Such movements have been identified from Gulf Coast chemical plants via the Arkansas River to a disposal site near Tulsa, Oklahoma. Indications are that the disposal of hazardous waste materials will become very controlled, to avoid future incidents such as the problem at Love Canal near Buffalo, New York. It is likely that specialized, licensed hazardous materials disposal sites will be created, and that water transport will often be employed because of favorable costs and because of lower accident rates than by rail or truck.

HAZARDOUS MATERIALS TRANSPORT REGULATIONS

There is an extensive body of laws and regulations governing the transport of hazardous materials by water, most of which have been codified or significantly revised in the 1970s. Present regulations cover the design, construction, equipment, manning, inspection and operation of vessels, unmanned barges and shoreside facilities transporting or handling hazardous cargoes; the packaging, marking, labeling, and preparation of shipping papers for transport; and the reporting, clean-up, surveillance and enforcement of oil and hazardous materials spills and discharges.

The most significant aspects of these regulations are their extent and complexity, leading to problems in enforcement and consistency of application. It is also noteworthy that the regulations are oriented primarily towards the mitigation of hazardous materials spills, and secondarily towards the prevention of accidents which would cause the spills.

A recent article in Marine Engineering/Log [42] provides an overview of hazardous materials regulations. In 1899, the United States Congress passed the Refuse Act, a powerful law prescribing criminal penalties for those proven guilty of discharging any refuse, including commercial cargo, into United States waters. Later Congressional actions were the Espionage Act of 1917, the Tank Vessel Act of 1936, and the Dangerous Cargo Act of 1940. These acts charged the United States Coast Guard with the missions of protecting designated waterfront facilities; regulating the bulk carriage of flammable and combustible liquids; and establishing guidelines for the handling, storage, and use of other bulk cargoes transported by water.

With the emergence of public safety and environmental protection as major issues, Congress passed numerous laws granting various federal agencies unprecedented authority to regulate the packaging, classification, storage, stowage, handling, marine transport, and shoreside transfer of hazardous materials. Major laws enacted to this end include the Ports and Waterways Safety Act of 1972, amended in the Port and Tanker Safety Act of 1978; the Hazardous Materials Transportation Act of 1974; and the Federal Water Pollution Control Act of 1972, amended in the Clean Water Act of 1977.

On October 21, 1971, following years of sustained negotiation, the Intergovernmental Maritime Consultive Organization (IMCO) adopted the "Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk." Based on United States Coast Guard hazardous materials research, the Code set strict global standards governing the design, construction, equipment, and crew safety standards aboard new and existing vessels transporting dangerous chemical cargoes. Most of the Code was incorporated into United States regulatory law on September 26, 1977.

To protect the transport of liquified natural gas (LNG) and liquified petroleum gas (LPG) in bulk on United States waters, the Coast Guard sought IMCO approval of global standards for the construction and design of bulk

gas carriers. On November 12, 1975, IMCO adopted the USCG-drafted "Code for Construction and Equipment of (New) Ships Carrying Liquified Gases in Bulk."

On October 4, 1976, the Coast Guard moved to adopt the IMCO code on new gas ships domestically, by publishing rules in the Federal Register for "Self-Propelled Vessels Carrying Bulk Liquified Gases."[42] On February 7, 1980, the Coast Guard published new regulations governing the design and location of LNG facilities, and proposed regulations to govern the operation of existing facilities. Regulations governing the operation of waterfront LNG facilities are expected.[44]

Figure V-B lists selected federal regulations which govern the transport of hazardous materials by vessels. Bulk liquids can be covered by several different sets of regulations, depending upon the type of material being transported. Basic provisions for all tank vessels (tankships and tank barges) are contained in 46 CFR Subchapter D. However, Subchapter O contains regulations for certain named commodities which may be in addition to, supplement, or modify other regulations. All unmanned barges carrying the commodities named in 46 CFR Part 151.01 must be inspected and certificated under the provisions of both Subchapter D and Subchapter O. A similar situation exists with respect to tankships for certain bulk liquids named in Part 153. Major commodities handled by water which fall under Part 151 include: acetic acid, acrylonitrile, anhydrous ammonia, benzene, butadiene, chlorine, ethylene dichloride, hydrochloric acid, phenol, propylene oxide, styrene, liquid (molten) sulfur, sulfuric acid, vinyl acetate, and vinyl chloride.

Figure V-B

Selected Hazardous Materials Regulations

49 CFR Subchapter C - Hazardous Materials Regulations
- Part 171 - General Information, Regulations, Definitions
- Part 172 - Hazardous Materials Table and Hazardous Materials Communications Regulations
- Part 173 - Shippers - General Requirements for Shipments and Packaging
- Part 176 - Carriage by Vessel
- Part 178 - Shipping Container Specifications

46 CFR Subchapter D - Tank Vessels
- Part 30 - General Provisions Part 31 - Inspection and Certification
- Part 32 - Special Equipment, Machinery, and Hull Requirements
- Part 33 - Lifesaving Equipment
- Part 34 - Fire Fighting Equipment
- Part 35 - Operations
- Part 36 - Elevated Temperature Cargoes
- Part 38 - Liquified Flammable Gases
- Part 39 - Special Construction, Arrangement, and Other Provisions for Carrying Certain Flammable or Combustible Dangerous Cargoes in Bulk

46 CFR Subchapter N - Dangerous Cargoes
- Part 146 - Transportation or Storage of Military Explosives On-Board Vessels
- Part 147 - Regulations Governing Use of Dangerous Articles as Ship's Stores and Supplies On-Board Vessels
- Part 148 - Carriage of Solid Hazardous Materials in Bulk

46 CFR Subchapter O - Certain Bulk Dangerous Cargoes
- Part 151 - Unmanned Barges Carrying Certain Bulk Dangerous Cargoes
- Part 153 - Safety Rules for Self-Propelled Vessels Carrying Hazardous Liquids
- Part 154 - Special Interim Regulations for Issuance of Letters of Compliance

One of the major features of Part 151 is the barge hull requirements. Four barge hull designs are specified: Type I for products requiring the maximum preventive measures to preclude uncontrolled release of the cargo; Type I-S for barges constructed or converted for the carriage of chlorine prior to July 1, 1964, but not upgraded to full Type I classification; Type II for products which require significant protection; and Type III for products requiring a moderate degree of protection. Detailed additional regulations governing operations and inspections for certain named materials are given in Subpart 151.50.

Safety Rules for Self-Propelled Vessels Carrying Hazardous Materials are contained in 46 CFR Part 153. This section incorporates most of the 1971 IMCO Code on bulk hazardous cargoes, with modifications developed in conjunction with the Coast Guard's Chemical Transportation Advisory Committee. The core of the Coast Guard's enforcement program for hazardous cargo transport in United States navigable waters is the Letter of Compliance (LOC) program. Dating back to 1965, this program requires that any foreign-flag vessel owner wishing to transport certain hazardous cargoes into or out of a United States port must first obtain Coast Guard approval, following careful review of vessel plans with respect to cargo containment and safety features. The equivalent of an LOC carried by United States-flag ships is the United States Coast Guard Certificate of Inspection.

Other Subchapters of 46 CFR apply to all cargo vessels. The most important of these are Subchapter E - Parts 42-46, Load Lines; Subchapter F - Parts 50-63, Marine Engineering; Subchapter I - Parts 90-98, Cargo and Miscellaneous Vessels; Subchapter J Parts 110-113, Electrical Engineering; and Subchapter Q - Parts 160-164, Specifications.

Another section of the Code of Federal Regulations (33 CFR Navigation and Navigable Waters, Chapter I - Coast Guard) contains navigation rules. One provision calls for all vessels carrying "certain dangerous cargoes" to notify the Captain of the Port of their arrival or departure at

least 24 hours in advance. The Coast Guard has exempted all vessels operating above Mile 235 on the Mississippi River (Baton Rouge, Louisiana) from this rule on an interim basis. Furthermore, barge operators must only report their arrival or departure four hours in advance, and only for 46 CFR Subchapter O commodities. All vessels under 1,600 gross tons are also now exempted.[45]

PROPOSED HAZARDOUS MATERIALS REGULATIONS

Continuing changes in hazardous materials regulations are likely for the foreseeable future, given the large number of proposed regulations now being advanced. The type of proposed change may be categorized in one of four groups, each of which is discussed in the sections which follow. In general, the trend is for more extensive and detailed regulations designed primarily to limit hazardous materials spills, and to reduce the risks of fires and/or explosions involving bulk materials. However, the cost-benefit trade-off is likely to become an issue in all these proposed rules.

(a) Consolidation of Existing Regulations

This change is sought to establish uniformity and consistency among existing regulations. Most notable among this category is the "Superfund" proposal to consolidate four existing programs related to oil spills, currently expressed as H.R. 85, the Oil Pollution Liability and Compensation Act. In 1976, Title 49 of the United States Code was revised to unify the labeling, packaging, and marking regulations for all modes of transportation. However, the standards are not totally in compliance with IMCO guidelines, which causes difficulties for international shipments.[46]

(b) Broadened Coverage

A second direction noted is the revision of existing regulations to encompass vessel types or other aspects now exempted, or to implement IMCO guidelines. For example,

the National Transportation Safety Board has proposed that tank barges and oceangoing tankers of over 1,600 gross tons be fitted with an inert gas system. The marine insurance industry supports the proposal, noting the high incidence of fire and explosion on barges and vessels under 20,000 deadweight tons, the lower size limit of existing regulations.

The Coast Guard has agreed to develop a plan to determine what steps should be taken to safeguard the tankers and tank barges. This will be accomplished in the two-part study entitled "Investigation of Hazards Posed by Chemical Vapors." expected to be released in February, 1982.[47]

In 1977 the Transportation Pollution Prevention Committee, a body established after the Argo Merchant disaster, made recommendations which resulted in Coast Guard regulations for oil tankers which are similar to, but more stringent than, those proposed by IMCO. They include the installation of double bottoms for tankers, segregated ballasts, and the installation of inert gas systems to prevent explosions. The regulations also call for improved steering equipment and radar standards to avoid collisions. Scheduled to take effect in 1981, the regulations will apply to vessels over 20,000 deadweight tons.[48]

(c) Extension of Regulations

The major new regulation now being proposed by the Coast Guard is entitled "Design Standards for New Tank Barges and Regulatory Action for Existing Tank Barges To Reduce Oil Pollution Due to Accidental Hull Damage," commonly referred to as the "double hull tank barge" proposal.[49] Its purpose is to effect a significant reduction in oil pollution of the navigable waters of the United States which results from hull damage to tank barges transporting oil. The proposal is designed as one step in the implementation of Title III of the Federal Water Pollution Control Act, which states:

"...it is the policy of the United States that there should be no discharges of oil or hazardous substances into or upon the navigable waters of the United States, adjoining shorelines, or into or upon the waters of the contiguous zone..."

The proposed regulations would require all new barges carrying oil and petroleum products to be built to additional standards above those now contained in 46 CFR Subchapter D (principally by requiring double hulls), and would phase out older (over 20 years) tank vessels during an interim period until the date when a total double hull fleet is required. The current proposal is a successor to a similar proposed regulation in 1971 which was not implemented due to unfavorable public comments, but which led to a joint MARAD/Coast Guard study of tank barge costs and damages from accidents [50] and the "Tank Barge Oil Pollution Study".[51]

Economic impacts (in 1978 dollars) of the current proposed rulemaking were estimated as:

1. $2.3 million in additional costs for new inland tank barges, assuming that by 1983 all inland barges would be voluntarily built with double hulls regardless of Coast Guard action.

2. $144 million in additional costs for new ocean and coastwise tank barges, for which no voluntary action is assumed.

3. $120 million for early replacement of existing inland tank barges; and,

4. $102 million for early replacement of existing ocean and coastwise barges.

These cost estimates are acknowledged as probably too low.

Industry opposition to the proposals has been vocal, with public comments ranging from "The very real possibility exists that I will be forced out of business," to statements that the proposals would contribute to inflation, hamper the transportation of petroleum products, waste natural resources, and fail to accomplish their stated objective of reducing oil pollution.[52] Serious opposition has developed for the following reasons:

1. The "Tank Barge Oil Pollution Study" and other reports have indicated that improper crew and terminal personnel operating procedures are as significant a cause of oil pollution as damage to the barge.

2. The types of vessel accidents which cause major oil spills will usually rupture double hulls, with the amount spilled only moderately reduced by the extra hull.

3. Void spaces in the double hull allow explosive vapors to collect.

4. Costs are underestimated and the associated benefits are not clearly established.

It is not known if the Coast Guard will eventually adopt these proposed regulations as currently formulated, will adopt a modified regulation, or will not proceed further.

(d) New Hazards

Another type of regulatory change that seems likely is the adoption of strict human exposure limitations on materials found to be carcinogenic. Benzene has been recognized for years as presenting both flammability and toxicity hazards, and tank barge regulations reflect this situation. Recently, benzene was discovered to be carcinogenic to laboratory animals at very low levels of vapor concentration. Accordingly, vapor limits have been greatly reduced and additional protective measures have been required for exposed workers.

In response, some inland water carriers ceased carriage of benzene rather than incur the extra costs for compliance with the new regulations. With the amount of research now under way to identify the toxic and carcinogenic properties of chemicals, it is highly likely that many commodities carried by water will be covered by new regulations designed to reduce human exposure.

The United States Occupational Safety and Health Administration (OSHA) has concluded that occupational safety and health standards may be needed to protect employees at grain handling facilities. OSHA is specifically concerned with fire and explosion hazards associated with grain handling and health hazards that may arise from exposure to grain dust, organic matter associated with grain, and pesticides used to treat grain. Public comments are now being solicited.

RISKS ASSOCIATED WITH HAZARDOUS MATERIALS

Direct hazards associated with the transport of hazardous materials have been characterized as one or more of the following types, varying in magnitude by the physical and chemical properties of the commodity being transported.

- Explosion.
- Fire.
- Vapor toxicity.
- Water toxicity.
- Chemical decomposition.

The risks include human exposure, property damage, and environmental degradation. Level of risk is a function of the probability of accidental release, the extent of the hazard produced, and situational factors related to the location of the release.

Risks associated with the transport and transfer of military explosives have been established by several major disasters. The Black Tom disaster at Jersey City, New Jersey, in 1917, and the explosion at Port Chicago, California, in 1944, led to the development of rigorous safety standards for the location and design of water terminals which handle large quantities of military explosives. Concerns over the potential damages resulting

from accidents involving liquified natural gas have led to similarly rigorous standards for the design of both LNG terminals and LNG vessels.

A major study was done by Arthur D. Little in 1974 [53] to assess the risks and costs associated with ten hazardous materials commonly transported in bulk by water, rail, truck, and pipeline. All ten materials studied cannot be removed from water, and are identified in a preliminary EPA list of substances hazardous to the marine environment. The ten materials evaluated were acrylonitrile, anhydrous ammonia, benzene, caustic soda, chlorine, ethylene glycol, methanol, styrene, sugar, and molten sulfur.

The study's safety assessment concluded:

"1. Barge transport generally involves less urban exposure than truck or rail.

2. In every one of the ten cases, the recurrence interval (years) between spill-causing accidents was longest for barge by a wide margin. Truck was usually next.

3. The relative human exposure index associated with the shipment of a hazardous substance entirely by one mode was, in most cases, least for barge, although truck was a close second. Only for the chlorine and benzene shipments was barge transport found to be more hazardous to people than truck transport.

4. The relative human exposure index associated with rail is substantially larger than that for either truck or barge.

5. Barge is the only transportation mode likely to present a water pollution hazard.

6. Expected annual property damage is about equally low for the barge and truck modes, and somewhat higher for rail.

7. Pipelines, represented in this study for only one material, were found to be accident-prone. However, this may be due to start-up problems that normally plague most new technological ventures."[53]

Further conclusions of the study relevant to the issue of barge spills of hazardous materials were:

"1. The barge mode of transport is apparently better inspected and regulated from a safety point of view than either truck or rail.

2. In the event that water transport of hazardous substances were to cease, present capacity of the overland modes of transport would not be sufficient to handle the overload. It would take a minimum of two and a half years, and probably much longer, to develop additional haulage capacity in the overland modes to accommodate the hazardous substances currently shipped by barge.

3. The future of barge transport of nonremovable hazardous substances may be contingent to a considerable degree on the penalties to be imposed by EPA. Another factor is whether it will be possible for the carrier or shipper to insure against these penalties."[53]

Environmental impacts evaluated were limited to toxic effects on marine organisms. Ethylene glycol, sugar, and molten sulfur had very limited toxic effects. The extent of toxic effects from other materials was estimated to range from 0.3 miles for methanol (wood alcohol) to 11 miles for benzene and 21 miles for chlorine. However, as the extent of toxic effects increased, the probability of a barge spill tended to decrease.

Hazardous materials spills in water present three special risk factors: once spilled, the material cannot be contained effectively and is usually not removable from the marine environment; fires and/or explosions in mid-stream cannot be easily controlled or extinguished; and the areal extent of environmental damage is the greatest of any mode. This poses a difficult problem for the shipper of hazardous materials because, although the probability of an accident occurring is lowest for water transportation, the damages from an incident will be greater than any other mode.

Interviews with shippers of chemical products reveal that most prefer the marine mode because of its low accident rate. However, one shipper refuses to ship hazardous materials by water because of the magnitude of potential liabilities should an accident occur.

A study by Booz-Allen and Hamilton [54] confirmed the observation that, on the basis of accident frequencies involving hazardous materials, barge is the safest mode, followed by rail and then truck. It also noted that the trend toward large shipment sizes would possibly increase the severity of a disaster involving hazardous materials.

Another important observation by Booz-Allen was that the study of hazardous materials accidents was in fact a study of accidents in general, since in no case did it appear that the cargo itself initiated an accident. This last point reveals clearly that the question of waterways hazardous materials safety is but a component of overall waterways safety.

The presence of hazardous materials greatly raises the risks associated with vessel control accidents. In the absence of hazardous materials, waterways accidents become simply an issue involving damages to vessels, cargoes and structures, and casualties to crew members or other persons, making them comparable to automobile accidents. The fact that waterways accidents are of much greater concern is due to the high volume of hazardous cargoes carried by water.

A case study of hazardous materials flows on the Gulf Intracoastal Waterway - West [55] found that the percentage of bulk materials classified as hazardous moving on that segment had increased from 92% to 95% from 1960 to 1970, with the total tonnage of hazardous materials more than doubling in the same period. A review of the waterways segments exhibiting high accident rates identified in Section IV indicates that essentially all such inland and coastal areas handle significant volumes of hazardous materials. Therefore, the segments with the greatest risks due to hazardous materials are those with high vessel casualty rates.

VI - POSSIBLE ACTIONS

A major objective of this research element is to develop a set of possible actions that could be incorporated into an overall waterways system strategy. Such actions address the waterways system requirements for national defense and other emergencies, and methods for improving waterways systems safety.

NATIONAL DEFENSE REQUIREMENTS

The only significant national defense requirements for the waterways system are to maintain access to key deep-draft ports and naval support facilities, and to move bulk materials required by manufacturing, electrical power generation, and agricultural industries. Providing a national dredging capability adequate for these requirements is the primary action required. Acquisition costs in 1980 dollars for the recommended minimum hopper dredge fleet have been estimated by the Construction Division of the United States Army Corps of Engineers South Pacific Division as follows:

1. One large class hopper dredge costs $77.5 million.

2. Four medium class hopper dredges, at $74.5 million each, cost $298 million.

3. Three small class hopper dredges, at $23 million each, cost $69 million.

Thus, some $445 million will be required to construct new hopper dredges for the federal fleet, and most likely more than $600 million will be needed to acquire all recommended dredge types.

The "Hopper Dredge Study" also estimated the amount of annual dredging required to maintain channels at major coastal ports. Table VI-1 shows the study's estimated dredging requirements for national defense. Some $42.5 million annually will be required to maintain chanels at seaports important to the national defense.

Table VI-1

Estimated Annual National
Defense Dredging Requirements

Region	Dredging Volume(1) (Thousands of Cubic Yards)	Annual Cost(2) ($ Millions)
East Coast	27,300	$ 21.7
Gulf Coast	9,900	7.9
West Coast	16,250	12.9
Subtotal	53,450	$ 42.5
Total United States(3)	298,000	$237.0

NOTES: (1) Average of years 1967-1977, hopper and cutterhead combined.
(2) Assuming 1977 average cost of $.795/cubic yard.
(3) As reported for all Corps and industry projects in FY 77.

SOURCE: Appendices 11 and 16, Hopper Dredge Requirements of the United States Army Corps of Engineers Minimum Fleet.

NONDEFENSE EMERGENCY REQUIREMENTS

An ability to respond to waterways systems disruptions is the principal nondefense emergency requirement. Potential responses include dredging and repair of structures in the aftermath of storms and flooding; icebreaking to keep important channels open; and diversion of cargoes in the event of disruption in the transportation system.

Dredging requirements are factored into the minimum federal dredge fleet decision, so no additional cost is involved. Flood and storm damage activities are incorporated into the budget of the Corps of Engineers. Corps Division expenditures in FY 78 under Public Law 84-99 are shown in Table VI-2. Icebreaking is a task built into the mission of the United States Coast Guard, and no new

actions are required. In addition, joint government-industry actions have been undertaken to combat river icing, and they impose no additional costs on the United States government.

Table VI-2

United States Army Corps of Engineers
Expenditures under P.L. 84-99

Fiscal Year 1978

Division	Planning	Emergency Operations	Repair and Rehabilitation	Advance Measures(1)
New England	$ 83,304	-	$ 63,294	-
North Atlantic(2)	196,893	15,642	1,228,877	-
South Atlantic(3)	269,061	31,243	-	-
Lower Mississippi Valley	248,441	54,462	563,792	42,108
Southwestern	188,586	33,725	209,734	-
Missouri River(4)	177,317	60,694	36[illegible],839	366,86[illegible]
Ohio River	162,674	265,96[illegible]	440,543	[illegible],148
North Central(5)	238,154	83,527	34,077	58[illegible],79[illegible]
South Pacific	191,369	148,388	1,940,496	[illegible]
North Pacific	220,729	862,778	2,708,091	-
Pacific Ocean	53,702	645	77,316	-
Totals	$2,050,230	$1,557,066	$7,628,059	$[illegible]40,787

Grand Total FY 78 Expenditures $12,476,142.
FY 78 Appropriations $18,000,000.

Notes:
(1) Primarily removal of ice dams.
(2) New York and Norfolk District expenditures not reported.
(3) Mobile District expenditures not reported.
(4) Kansas City District expenditures are for FY 77 and FY 78.
(5) Detroit District expenditures not fully reported.

Source: FY 1978 Annual Report of the Chief of Engineers on Civil Works Activities.

Altogether, continuing expenditures by the Corps of Engineers for nondefense emergency activities will be in the range of $10-$20 million annually.

IMPROVE WATERWAYS SAFETY

Actions designed to improve waterways safety emphasize programs which tend to reduce the likelihood of waterways accidents, and which reduce the associated damages when accidents do occur.

(a) Reduced Frequency of Accidents

1. Training and Licensing. In order to reduce the likelihood of accidents, the most promising actions are those which improve the training of vessel crews and terminal workers. Such training is important since human error has been found to be the major cause of waterways accidents, especially vessel control accidents. The waterways industry is already undertaking improved training programs for a variety of reasons, with personnel turnover and insurance costs the most notable. An associated Coast Guard program is vessel crew licensing, which emphasizes the demonstration of both training and job skills for workers handling hazardous materials.

Given the wide variety of training programs, the indirect costs borne by employers, and the lack of comprehensive information on this subject, a very rough estimate of current training and licensing costs would be $5,000 to $10,000 per person for the inland marine carriers, and three to five times that amount for ocean carriers. These costs must be factored into the upgrading training of a crew member during his career.

2. Waterways System Design. Waterways system design also influences the probability of vessel casualties. Bends, channel intersections, and bridges tend to increase the rate of vessel accidents, especially when they appear in combination near each other. The waterways system can be reconstructed to reduce these hazards. Detailed cost estimates for waterways system improvements, as well as dredging costs, are contained in Element K1 - Analysis of Waterways System Navigational Capability.

3. Vessel Traffic Services. Vessel traffic services provide for greater waterways safety, and are especially effective in constricted areas with a high level of vessel traffic. A passive VTS, with basic position reporting to the United States Coast Guard, has relatively small acquisition costs and operating costs approximating $100,000 per year. The most sophisticated VTS with computer-assisted radar tracking can cost $10 million to install, with about $1 million annually in operations costs.

4. Vessel Improvements. Improved vessel steering, communication, and navigation systems also can reduce

the frequency of vessel casualties. Costs for such improvements are not easily defined, but rough estimates for shipboard radar systems are $25,000 to $50,000 for towboats and $750,000 to $1,250,000 for ocean vessels. In any case, the expenditures for such improvements will be borne primarily by the vessel owners and operators.

5. Navigation Improvement. Other actions which could help to reduce vessel casualties include improved navigation aids, radar reflectors on bridge piers and other structures, simplified and expanded navigation rules, and mandatory bridge-to-bridge communications in "blind" navigation situations. Costs of such programs are minor with the exception of improved navigation aids, which could cost millions of dollars. A minimal cost action to improve hazardous materials safety would involve simplification and standardization of hazardous materials regulations.

(b) Reduced Damages from Accidents

Two steps are available to reduce damages from waterways system accidents. One direction is to improve the design of vessels to prevent spillage of liquid bulk cargoes or to better tolerate impacts. The magnitude of such costs is indicated by the United States Coast Guard's proposed regulation requiring double hull tank barges for the carriage of oil and petroleum products. Costs to the marine towing industry were estimated at $400 million or more.

An effective vessel inspection and certification program is a key element in a preventive vessel safety program. The General Accounting Office, in a review of the United States Coast Guard's vessel inspection program, estimated that the total inspection work load in 1977 was over 16,000 man-hours. Expanded vessel design and inspection standards represents the major direction taken by the federal government to reduce the risks associated with hazardous materials transport. Adequate funding and staffing are required in order to ensure the effectiveness of such programs.

The other direction for reducing damages is to upgrade protection systems and locks, dams, bridges, and other

structures. To some extent, improved protection systems have not been installed at bridges because the bridge owners are totally responsible for their provision and maintenance, and often the owner cannot recover damages to the systems from vessel owners and operators. Improved fendering and other impact-absorbing systems can represent a significant cost; information on their costs may be found in the Element K1 report.

Locks and dams are especially vulnerable to vessel accidents, and the potential exists for major direct and indirect damages if a major fire and/or explosion should occur. Improved approaches to locks, additional protective systems, and fire protection systems should be considered, especially at sites which handle large volumes of hazardous materials. Costs of such systems are substantial; for example, the provision of a water spray system for lock gates and a foam monitor nozzle to suppress lock fires is estimated to cost approximately $700,000 for installation, and $11,000 in annual maintenance.

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VII - CONCLUSIONS

Three waterways topics have been addressed in this NWS element: national defense requirements, nondefense emergency requirements, and waterways system safety, including hazardous materials issues. Conclusions are presented for each topic.

NATIONAL DEFENSE REQUIREMENTS

National defense requirements for the waterways system vary by the type of waterway, and are further differentiated by peacetime and contingency periods. Presented below are conclusions for each type of waterway, followed by general conclusions.

1. Inland Waterways. Department of Defense (DOD) usage of the inland waterways system during a military contingency will be minor. Principal DOD transportation requirements are for rapid movements of unit equipment and resupply cargoes to deep-draft ports on the Atlantic and Pacific coasts, in contrast to the relatively slow speeds and North-South orientation of the inland waterways system.

Certain movements of stockpiled bulk raw materials used in the aluminum and iron and steel industries may occur, although most potential origins lack water terminal facilities. The inland system will continue to move significant quantities of bulk materials used by the general economy, in particular those commodities essential to the metals manufacturing, electrical production, petroleum refining, chemicals manufacturing, and agricultural industries. At times, the inland system may be used to relieve overloads on other modes, especially rail.

2. Intracoastal Waterways. Fuel movements by the Defense Fuel Supply Center (DFSC) on intracoastal waterways and in bay areas represent over 95% of shallow-draft traffic shipped by DOD. Occasional movements of jet engines and other machinery on the same waterways also occur.

During a military contingency, the intracoastal waterways can be expected to continue to move fuel to key

bases, such as Dover Air Force Base, and may carry major amounts of stockpiled bauxite in the Gulf Coast area. Otherwise, the national defense requirements for the intracoastal waterways will be the same as those noted for the inland waterways.

3. Great Lakes. Current DOD usage of the Great Lakes is limited to small volumes of jet fuel moving to Air Force bases in Michigan. Great Lakes shipyards provide additional merchant marine and naval construction capabilities.

Military contingency requirements are principally the movement of iron ore, limestone and coal associated with the steel industry going to ports on Lakes Michigan and Erie. Iron ore shipments from Quebec and Ontario to the same ports may also occur. Great Lakes shipyards and deep-draft ports will supplement the facilities on the seacoasts. Fuel movements by DFSC can be expected to continue, as will bulk commodity shipments associated with energy production, agriculture, and the steel industry.

4. Coastal Ports. Current DOD usage of the waterways system consists of military supplies moving overseas through commercial and military deep-draft ports, fuel shipments via Military Sealift Command tankers from refineries to deep-draft distribution terminals operated by DFSC, and access to naval bases and shipyards by the United States Navy. Contingency requirements are essentially a continuation of the same uses, but at a much higher level of demand. Additionally, the coastal ports will continue to move cargoes important to the general industrial base of the nation, although import and export trade may decline significantly.

5. Dredging. Provision of an adequate dredging fleet capable of maintaining the channels at major coastal ports, in key Great Lakes ports and connecting waterways, and on the major intracoastal and inland waterways, is the single important national defense requirement that must be addressed by the National Waterways Study.

6. Transportation Allocation Procedures. Existing regulations governing the control and allocation of civil transportation resources during a national defense emergency call for extensive data collection and submission, require several levels of review and comment, and split control authority over the various modes among a

variety of federal agencies. These regulations are probably not effective for the high demand, rapid response environment of a major military contingency.

NONDEFENSE EMERGENCY REQUIREMENTS

No federal nondefense emergency plan contains a specific requirement for the waterways system. Planning for natural disasters, storms, civil disruptions, and other emergencies emphasizes instead a flexible response by those local officials who direct relief and assistance activities. However, there are some general requirements for the waterways system in a nondefense emergency.

1. The waterways system should be capable of the movement of priority materials, such as fuels and water purification materials, and any other materials, as directed.

2. The Corps of Engineers should have up-to-date emergency plans and stockpiles of materials needed for flood fighting and repair of storm damages, as provided for in existing laws and regulations.

3. The Corps of Engineers should provide equipment and manpower needed to repair and reopen the waterways system whenever it is damaged, as required by existing laws and regulations.

4. In general, personnel should be prepared to assist local relief efforts in emergency situations, in such ways as personnel evacuations and damage assessments.

WATERWAYS SYSTEM SAFETY

"Safety" in this report references only accidents classified as vessel casualties. The major reason for examining this topic is to find methods for reducing both the incidence of and damages from vessel casualties which are appropriate within the context of the NWS. Conclusions presented herein reflect this limitation in scope. Safety problems observed in each of the NWS regions are noted in Exhibit VII-1.

1. Location of Accidents. The majority of all vessel casualties occur in a relatively few segments of the waterways system. These high accident segments are characterized by the presence of bends, channel intersections, bridges, locks and dams, terminal facilities, narrow channels, and heavy vessel traffic. These segments represent the priority locations for any waterways system accident reduction strategy.

The Gulf Intracoastal Waterway from Galveston, Texas to its intersection with the Mississippi River Gulf Outlet, and the Mississippi River below Baton Rouge, Louisiana, represent the greatest concentration of waterways system accidents. Other inland segments with high accident rate areas are the Lower and Upper Mississippi River, the Ohio River, and the Illinois Waterway. Deep-draft accidents occur primarily in harbor areas and their entrance channels.

2. Causes of Accidents. Human errors by persons-in-charge are the major cause of vessel casualties. Failures to perform essential tasks are the major cause of collisions, while rammings and groundings typically occur because the person-in-charge improperly evaluates the navigation conditions. Other major causes of vessel casualties are equipment failures, unmarked submerged objects or shoals, weather, ice, and unusual currents.

3. Risks from Accidents. The greatest risks from waterways system accidents are associated with vessel control accidents - groundings, rammings, and collisions - which involve a cargo of hazardous materials. The magnitude of potential losses increases rapidly with the presence of populated areas subject to fires, explosions, and toxic vapors. Risks also increase when bridges, piers, locks and dams, or anchorage areas are present, because they increase the likelihood and severity of vessel control accidents. The predominant issue regarding hazardous materials for the NWS is the damages they can cause when involved in an accident.

4. Hazardous Materials Regulations. Regulations governing the transport of hazardous materials are extensive, detailed, and confusing. Separate rules are issued by the Materials Transport Bureau, the United States Coast Guard, the Environmental Protection Agency, and the Occupational Safety and Health Agency, and they are not always in conformance with international standards. Strict

compliance is extremely difficult, and a shortage of qualified inspectors and a lack of uniform rules interpretations seriously compromises compliance.

Strict interpretation of liability for hazardous materials discharges, with no limitation on damages, raises serious financial difficulties for carriers and terminal operators.

5. Hazardous Materials Safety. Water transportation of hazardous materials exhibits a better accident history than other modes. However, once hazardous materials accidents occur on the waterways, the effects (spills and fires) are difficult to contain, and the potential for major damages is very high.

WATERWAYS SAFETY PROBLEMS BY NWS REGION

Region	Observed Safety Problems
Upper Mississippi	Groundings near mouths of tributary rivers and in twisting channels.
	Bridge rammings at movable bridges, plus railroad bridges at Quincy, Illinois, and Burlington, Iowa.
	Congestion in the Quad Cities and Twin Cities areas.
Lower Upper Mississippi	Bridge and vessel rammings in the St. Louis area.
	Groundings from Cairo, Illinois to Ste. Genevieve, Missouri.
	Bridge rammings at Thebes, Illinois and Ste. Genevieve, Missouri.
Lower Mississippi	Bridge rammings at Natchez, Vicksburg and Greenville, Mississippi.
	Large volume of hazardous materials traffic.
	Groundings in areas where the channel is unstable and below major bends.
Baton Rouge to Gulf	Collisions and vessel rammings at the mouths of the Mississippi and in the New Orleans area.

Region	Observed Safety Problems
Baton Rouge to Gulf (Continued)	Heavy traffic compounded by a mix of deep-draft ships and tows.
	Large volume of hazardous materials traffic.
	Heavy use of radio communications channels.
	Congestion at locks entering the GIWW.
	Narrow movable bridges on Black/Ouachita, Atchafalaya River, and Port Allen-Morgan City Alternate Route.
Illinois Waterway	Bridge rammings at narrow movable spans.
	Congestion and narrow channels at the Peoria, Joliet, and Lockport area.
	Groundings near Morris, Marseilles, and the mouth of the Kankakee River.
	Narrow bridges on Chicago Sanitary and Ship Canal.
Missouri River	Bridges, bends and docks in Kansas City area, plus intersection with Kansas River.
	Narrow movable railroad bridges above Kansas City.

Region	Observed Safety Problems
Ohio River and Tributaries	Rammings and collisions near Emsworth, Dashields, New Cum- Gallipolis, McAlpine, Newburgh, and Smithland L/Ds, plus L/Ds 50-53.
	Groundings on Ohio River below Newburgh L/D.
	Congestion in Pittsburgh, Huntington, Cincinnati, Louisville, Paducah, and Cairo areas.
	Narrow railroad movable bridges on Green River, Cumberland River, and near Mc-Alpine L/D.
Tennessee River	Rammings at bridges near Decatur, Alabama; also at bridges over Kentucky Lake due to wind.
	Narrow channel in rock cuts above Chattanooga, Tennessee.
Arkansas and White Rivers	Rammings and groundings from Arkansas River L/D 2 to mouth.
	Narrow movable bridges on White River.
Gulf Coast West	High accident rate on GIWW from Galveston to New Orleans, due to heavy traffic, narrow channels, narrow bridges, channel intersections, and bends.

Region	Observed Safety Problems
Gulf Coast West (Continued)	Very high volume of hazardous materials traffic.
	Mix of deep-draft and shallow-draft vessels at Lake Charles, Beaumont-Port Arthur-Orange, Houston Ship Channel, and Corpus Christi areas.
	Rammings at locks and floodgates on GIWW.
	Collisions at entrance to Houston Ship Channel.
	Rammings of offshore structures and navigation aids.
	Groundings on GIWW in shallow bay reaches.
Gulf Coast East	Mix of deep-draft and shallow-draft vessels in New Orleans, Pascagoula, Biloxi, and Mobile port areas.
	Congestion at GIWW locks in New Orleans.
	Groundings on GIWW in land cuts and on Mississippi Sound.
	Bridge rammings on Inner Harbor Navigation Canal and at Dauphin Island, Alabama. (Dauphin Island bridge destroyed by Hurricane Frederic; to be replaced.)

Region	Observed Safety Problems
Gulf Coast East (Continued)	Moderate volume of hazardous materials traffic from New Orleans to Pensacola. Frequent groundings in Tampa area. Narrow bridges on Okeechobee Waterway and Intracoastal Waterway from Ft. Myers, Florida to Anclote River, Florida.
Black Warrior-Tombigbee and Alabama-Coosa Waterways	Shoaling and unstable channels, with sharp bends. Narrow bridges.
South Atlantic Coast	Rammings and collisions at deep-draft ports. Frequent groundings near Cape Fear and Cape Hatteras, although they occur throughout the region.
Middle Atlantic Coast	Frequent groundings near Assateague, Virginia and the Delaware River, as well as in Hampton Roads, Baltimore, and New York harbor areas, although they occur throughout the region. Collisions in Chesapeake Bay and New York harbor areas. Bridge rammings on Elizabeth River (Norfolk-Portsmouth, Virginia). Heavy vessel traffic at deep-draft ports.

Region	Observed Safety Problems
Middle Atlantic Coast (Continued)	Heavy volume of oil and petroleum products traffic at Philadelphia and New York areas.
North Atlantic Coast	Frequent groundings and pier rammings by fishing vessels.
	Bridge rammings at New Haven, Connecticut and Portland, Maine.
	Icing during winter.
Great Lakes/St. Lawrence Seaway/New York State Waterways	Groundings in St. Lawrence Seaway, New York State Waterways, Detroit-St. Clair Rivers, and St. Mary's River.
	Bridge rammings in Detroit-St. Clair Rivers and St. Mary's River (Soo Locks).
	Pier rammings at larger Lakes ports.
	Icing during winter.
Washington/Oregon Coast	Rammings in Puget Sound ports.
	Fishing vessel groundings at Oregon ports on Pacific Ocean.
	Poor weather in Puget Sound, plus heavy crude oil traffic.
Columbia-Snake Waterway and Willamette River	Collisions and rammings in deep-draft section of Columbia River.

Region	Observed Safety Problems
Columbia-Snake Waterway and Willamette River (Continued)	Groundings throughout the region.
California Coast	Groundings and rammings in San Francisco Bay area.
	Collisions near San Francisco and Los Angeles/Long Beach port areas, plus heavy volume of oil and petroleum products traffic.
	Groundings throughout the region.
Alaska	Fishing vessel groundings and pier rammings at Pacific Ocean ports.
	Heavy oil traffic from Valdez and Kenai areas.
Hawaii and Pacific Territories	Groundings at Hawaiian ports.
Puerto Rico and Virgin Islands	Groundings and pier rammings at San Juan, Puerto Rico.
	Heavy oil and petroleum products traffic at Virgin Islands.
	Groundings at Guayanilla Bay, Puerto Rico.

SOURCE: NWS Analysis of United States Coast Guard Marine Casualty Records, FY 77-78.

VIII - RECOMMENDATIONS FOR FURTHER INVESTIGATION

During the research for this National Waterways Study report, certain topics were uncovered which warrant additional investigation. This section lists those topics and suggests the types of investigation that could be conducted. The order in which recommendations are listed does not imply a ranking; all are important.

1. United States-Owned Dredge Fleet. In the "Hopper Dredge Requirements" study, several critical assumptions were made which tended to reduce the size of the minimum required dredging fleet. Such assumptions included: no allowance for dredge repositioning movements within a region; defense and other types of emergencies would not occur simultaneously; potential damages to dredges were not considered; and overseas and United States defense requirements would not occur at the same time. Furthermore, dredging work loads for the United States Navy and for shallow-draft fuel terminals used by the Defense Fuel Supply Agency are not mentioned.

The Corps of Engineers should confirm that the recommended minimum dredge fleet is adequate in light of these factors, and should specifically include these factors in its studies of the minimum fleet sizes for other dredge types.

2. Emergency Resource Allocation Procedures. Existing national emergency resource allocation procedures for civil transportation require the submission of requirements and capabilities assessments several weeks in advance of the date that a movement is scheduled to occur. Given the very heavy transportation demands that would occur in the early stages of a major military contingency as unit equipment and supplies are deployed overseas, the existing procedures may prove to be unacceptable. Another major weakness of current procedures is the requirement for review of transportation requests by several agencies within the Department of Defense before assets are allocated.

The Departments of Defense and Transportation should review and test these procedures and modify them, as necessary, to produce an effective control system. To the maximum extent feasible, advance authorizations for

planned unit equipment and supply movements should be developed in conjunction with military contingency plans.

3. Strategic Materials Movements. The Federal Emergency Management Agency has stockpiles of bulk strategic raw materials at several locations which could effectively use the waterways system during contingencies. However, most of these locations do not have water terminal facilities and thus cannot ship via water. FEMA should investigate the feasibility of acquiring water shipment capabilities at the following locations: Savanna Army Depot Activity, Savanna, Illinois; GSA Depot, Point Pleasant, West Virginia; GSA Leased Site, Clairton, Pennsylvania; Seneca Army Depot, Kendaia, New York; Installation Support Activity, Granite City, Illinois; Defense Depot, Memphis, Tennessee; GSA Depot, Baton Rouge, Louisiana; GSA Depot, Curtis Bay, Maryland; and GSA Depot, Port Clinton, Ohio.

4. Vessel Control and Response. Many vessel control accidents (groundings, collisions, and rammings) occur because of difficulties in navigating vessels at low speeds and against the effects of current and wind. Existing technology does not provide useful measures for overcoming these difficulties. Research should be conducted to provide improved vessel steering systems, to develop useful equipment which can measure current and wind effects, and to develop a better understanding of vessel response characteristics in constricted channels.

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GLOSSARY

Casualty: A casualty is an accident involving a commercial vessel which is reported to the United States Coast Guard whenever any of the following occur:

1. Actual physical damage to property in excess of $1,500.

2. Material damage affecting the seaworthiness or efficiency of a vessel.

3. Stranding or grounding (with or without damage).

4. Loss of life.

5. Injury causing any persons to remain incapacitated for a period in excess of 72 hours; except injury to harbor workers not resulting in death and not resulting from vessel casualty or vessel equipment casualty.

Clean Product: A term applied to refined petroleum products (specifically gasoline, kerosene, jet fuel and distillate fuel) which can be transported successively and interchangeably in the same tank without the need for tank cleaning between loadings.

COLREGS: An acronym for the International Regulations for Preventing Collisions at Sea 1972, which became effective in the United States on July 15, 1977.

Containerization: A method of handling cargo which has been loaded in a container of standard dimensions, with subsequent handling and stowage performed on the container itself; containers are designed to the specifications of the International Organization for Standardization (ISO) for either marine or air freight service.

Deep-Draft: Vessels which draw at least 20 feet of water; also, channels which provide at least 20-foot depth at Mean Low Water levels.

DFSC: Defense Fuel Supply Center, a component of the Defense Logistics Agency, which is the sole procurement source worldwide for the Department of Defense (DOD).

DFSP: Defense Fuel Supply Point, a petroleum terminal operated by or for DFSC which is used for the distribution of DOD fuel.

Emergency: Any action or natural event which can stop or disrupt the transportation system.

FEMA: The Federal Emergency Management Agency, an independent agency established by the Reorganization Plan of 1978 and Executive Orders 12127 and 12148, which provides a single point of reference for all federal emergency preparedness, mitigation and response activities.

Hazardous Material: A substance or material which has been determined to be capable of posing an unreasonable risk to health, safety and property when transported in commerce.

IMCO: The Intergovernmental Maritime Consultative Organization, a specialized agency of the United Nations which is concerned solely with maritime affairs; through IMCO, international conventions have been drafted governing pollution prevention from ships, safety of life at sea, and prevention of collisions at sea.

LASH: The acronym for the Lighter Aboard Ship marine transport system; elements of the system are lighters 61 feet 6 inches long, 31 feet 2 inches wide and loaded draft of 8 feet 7 inches which can carry 369 long tons of cargo, and special design ships on which the lighters are stowed; a 550-long-ton-capacity gantry crane aboard the ship lifts the lighters at the stern and stacks them in cells, stowing them athwartship throughout the ship.

LDT: Long dry ton; a measure of the standard weight of a material after it has been dried under specified conditions to eliminate excess moisture, expressed in units of 2,240 pounds.

Long Ton: A weight measure of 2,240 pounds.

Measurement Ton: A volume measure of vessel cargo-carrying capacity in units of 40 cubic feet.

Military Contingency: A description of a potential military conflict involving United States forces which includes location, scope of conflict, and other pertinent factors that are used to determine unit composition, deployment needs, and resupply material demands.

MSC: The Military Sealift Command, an element of the United States Navy which is responsible for procuring all sea transportation services for the Department of Defense, and which operates a nucleus fleet of cargo ships, tankers and naval auxiliaries in areas where commercial shipping is not available.

MSTS: The Military Sea Transportation Service, the former designation of the current Military Sealift Command.

MTMC: The Military Traffic Management Command, a jointly staffed agency of the United States Army which procures all surface transportation service in the United States for the Department of Defense, operates military-owned ocean terminals in the United States and overseas, and routes all Department of Defense passenger and cargo traffic.

National Defense: In its broadest sense, national defense is a combination of military forces, industrial and agricultural production capability, and intergovernmental relationships which enhance the security and independence of the United States.

NDRF: The National Defense Reserve Fleet, administered by the Maritime Administration of the Department of Commerce, is composed of about 200 cargo ships and naval auxiliaries which are preserved at three sites - James River, Virginia, Beaumont, Texas and Suisun Bay, California; about 20 ships are capable of being activated within 5-10 days, the remainder in approximately 30-90 days.

NETC: The National Emergency Transportation Center is an organization that would be formed by the United States Secretary of Transportation, in the event of a declared national emergency, to provide centralized direction of all federal emergency transportation activities.

Region: An area encompassing several National Waterways Study analysis segments for which findings related to its included waterways are reported; a total of 22 regions have been defined for the NWS.

Rules of the Road: A set of navigation requirements designed to prevent collisions between vessels; revised International Regulations for Preventing Collisions at Sea were developed by IMCO in 1972 and adopted as a treaty by the Senate, effective in 1977; Rules of the Road for United States waters are defined by United States statute, and three different sets of rules apply in different areas - Inland, Great Lakes and Western Rivers; recodification to combine all United States Rules of the Road is being considered by Congress in the bill H.R.6671.

Safety: Actions which act to prevent accidents involving people and property, or which tend to mitigate the amount of damages arising from an accident.

SDT: Short dry ton; a measure of the standard weight of a material after it has been dried under specified conditions to eliminate excess moisture, expressed in units of 2,000 pounds.

SEABEE: The acronym for the Sea Barge marine transport system; elements of the system are barges 97 feet 6 inches long, 35 feet wide, and loaded draft of 10 feet 7 inches which can carry 834 long tons of cargo, and special design ships which transport the barges; a 2,000-long-ton-capacity submersible elevator at the ship stern lifts two barges to one of three decks; barges are moved from the elevator to stowage positions by rail-mounted transporters which lift the barges from beneath, stowing them lengthwise in two rows on each deck.

Segment: One of 61 areas of the waterways system defined for the National Waterways Study in which navigation characteristics are relatively similar, and which represents the level at which detailed analysis was conducted.

Shallow-Draft: Vessels which draw less than 20 feet of water; also channels which provide no more than 20-foot depth at Mean Low Water levels.

Short Ton: A weight measure of 2,000 pounds.

Strategic Materials: Materials which are essential to supply the military, industrial and essential civilian needs of the United States for national defense; the Strategic and Critical Materials Stockpiling Act authorizes the acquisition and retention of stocks of certain strategic and critical materials to decrease dependence upon foreign sources for supplies of such materials in times of national emergency.

VTS: Vessel Traffic Service, an active vessel traffic monitoring or control system operated by the United States Coast Guard which is designed to reduce collisions, rammings and groundings in specific waterways areas.

APPENDIX A

BARGE MOVEMENTS OF FUEL BY DFSC

FISCAL YEAR 1978

NATIONAL WATERWAYS STUDY,
ELEMENT E/F

Barge Movements of Fuel by DFSC, FY 78

Activity	Location	Shipped (Gallons)	Received (Gallons)
Exxon Co. (R)	Baton Rouge, Louisana	836,388	-
Plantation pipeline Co. (T)	Baton Rouge, Louisana	-	44,381,461
NAS New Orleans	New Orleans, Louisana	-	1,908,667
Arkansas ANG, Adams Field	Little Rock, Arkansas	-	2,588,826
Sun Petroleum Products Co. (R)	Corpus Christi, Texas	17,713,677	-
GATX Terminals Corp. (T)	Pasadena, Texas	44,802,289	16,085,941
Marion Corp. (R)	Pasadena, Texas	20,015,973	-
Chevron U.S.A., Inc. (R)	Pascagoula, Mississippi	106,005,093	-
DFSP Lynn Haven	Lynn Haven, Florida	-	119,324,972
NAS Pensacola	Pensacola, Florida	-	4,605,125
DFSP Jacksonville	Jacksonville, Florida	126,066,552	-
Mayport Naval Station	Mayport, FL	-	48,463,372
NAS Jacksonville	Yukon, Florida	-	59,355,740

NATIONAL WATERWAYS STUDY,
ELEMENT E/F

Barge Movements of Fuel by DFSC, FY 78

Activity	Location	Shipped	Received
Naval Shipbuilding and Repair Activities	Jacksonville, Florida	-	124,864
MCAS Beaufort	Beaufort, South Carolina	-	18,122,576
Charleston Naval Shipyard	Charleston, South Carolina	-	357,826
MCAS Cherry Point	Cherry Point, North Carolina	-	2,322,586
DFSP Norfolk	Norfolk, Virginia	1,043,032	-
DFSP Craney Island	Portsmouth, Virginia	82,660,340	-
DFSP Yorktown/Amoco Oil (R)	Yorktown, Virginia	55,136,376	-
Langley AFB	Hampton, Virginia	-	35,090,238
NAS Norfolk	Norfolk, Virginia	-	26,661,343
NAB Little Creek	Norfolk, Virginia	-	7,401,808
NSC Norfolk	Norfolk, Virginia	-	25,302,465

NATIONAL WATERWAYS STUDY,
ELEMENT E/F

Barge Movements of Fuel by DFSC, FY 78

Activity	Location	Shipped (Gallons)	Received (Gallons)
Norfolk Naval Shipyard	Portsmouth, Virginia	-	36,102,703
Newport News Shipbuilding & Drydock Co.	Newport News, Virginia	-	763,644
Virginia ANG, Byrd Field	Sandstone, Virginia	-	656,257
DFSP Piney Point	Piney Point, Maryland	29,206,095	46,436,231
NAS Patuxent River	Lexington Park, Maryland	-	14,213,642
Sun Petroleum Products Co. (R)	Marcus Hook, Pennsylvania	136,798.961	-
Getty Refining & Marketing Co. (R)	Delaware City, Delaware	64,943,063	-
DFSP Port Mahon/Delaware Storage & Pipeline Co. (T)	Port Mahon, Delaware	-	65,827,518
DFSP Burlington/Interstate Storage & Pipeline Co. (T)	Burlington, New Jersey	-	109,367,101
DFSP Port Reading/Amerada Hess Corp. (T)	Port Reading, New Jersey	42,984,461	-

NATIONAL WATERWAYS STUDY,
ELEMENT E/F

Barge Movements of Fuel by DFSC, FY 78

Activity	Location	Shipped (Gallons)	Received (Gallons)
Plattsburgh AFB	Plattsburgh, New York	-	37,712,669
Vermont ANG	Burlington, Vermont	-	4,615,535
DFSP Verona (T)	Verona, New York	231,729	-
Griffiss AFB	Rome, New York	-	231,729
DFSP Melville Terminal	Portsmouth, Rhode Island	4,710,330	-
NSC Newport	Newport, Rhode Island	-	668,412
Atlas Oil Co. (W)	Boston, Massachusetts	9,212,585	-
United States Navy	Boston, Massachusetts	35,278	-
General Electric Co.	West Lynn, Massachusetts	-	6,339,645
DFSP Newington/ATC Oil Co. (R)	Newington, New Hampshire	1,906,188	-
DFSP Searsport (T)	Searsport, Maine	-	9,212,585

NATIONAL WATERWAYS STUDY,
ELEMENT E/F

Barge Movements of Fuel by DFSC, FY 78

Activity	Location	Shipped (Gallons)	Received (Gallons)
DFSP Casco Bay	Harpswell Neck, Maine	863,391	-
United States Naval Ships	New England Area	-	391,898
Total Petroleum Co. (R)	Bay City, Michigan	14,748,570	-
DFSP Harrisville	Harrisville, Michigan	-	6,777,349
DFSP Escanaba (T)	Escanaba, Michigan	-	7,971,221
Mobil Oil Co. (R)	Ferndale, Washington	8,982,768	-
DFSP Mukilteo	Mukilteo, Washington	34,587,795	8,982,768
NAS Whidbey Island	Oak Harbor, Washington	-	28,784,882
DFSP Puget Sound	Manchester, Washington	20,171,519	35,735,198
United States Naval Vessels	Puget Sound, Washington	-	6,059,634
United States Oil & Refining Co. (R)	Tacoma, Washington	24,061,363	-

NATIONAL WATERWAYS STUDY,
ELEMENT E/F

Barge Movements of Fuel by DFSC, FY 78

Activity	Location	Shipped (Gallons)	Received (Gallons)
Buckeye Pipeline Co. (T)	Tacoma, Washington	-	43,976,161
Exxon Co. (R)	Benicia, California	45,549,389	-
Pacific Refining Co. (R)	Hercules, California	10,403,058	-
Chevron U.S.A., Inc. (R)	Richmond, California	25,039,219	-
DFSP Point Molate	Richmond, California	22,412,699	50,425,490
NAS Alameda	Alameda, California	-	350,000
Federal Vessels and Activities	San Francisco Bay Area	-	16,893,677
Powerline Oil Co. (R)	Long Beach, California	3,132,771	-
NCBC Port Hueneme	Port Hueneme, California	-	770,081
NSC Point Loma	San Diego, California	-	2,362,690
North Pole Refining Co. (R)	North Pole, Arkansas	4,441,060	-
Transshipment Point	Nenana, Arkansas	-	4,441,060

SOURCE: Unaudited records of the Defense Fuel Supply Center.

ABBREVIATIONS:
AFB - Air Force Base
ANG - Air National Guard
DFSP Defense Fuel Supply Point
MCAS - Marine Corps Air Station
NAB - Naval Amphibious Base
NAS - Naval Air Station
NCBC - Naval Construction Battalion Center
NSC - Naval Supply Center
(R) - Refinery
(T) - Pipeline Terminal
(W) - Petroelum Wholesaler

APPENDIX B

SELECTED WATERBORNE COMMODITY MOVEMENTS - 1969 - 1977

Data presented in this appendix comprises tables of annual tonnages moving between geographic regions. Regions noted on the left side of the tables indicate origins, with the sum across a row indicating total exports from the region. Regions along the top are destinations, with column totals being regional imports. The following list indicates the regions used to produce the table.

Number	Region
1	Southeast United States
2	Northeast United States
3	Great Lakes
4	Texas Coast
5	Lower Mississippi River
6	Upper Mississippi River
7	Ohio River
8	Pacific Coast
9	Alaska, Hawaii and Puerto Rico
10	Rest of World
11	Unknown

COMPRESSED1311

CRUDE PETROLEUM

1969	1	2	3	4	5	6	7	8	9	10	11	SUM
1	703,350	1,015,474	0	268,864	921,100	0	0	0	0	0	0	3,888,035
2	0	3,115,441	0	0	0	0	0	0	0	933	0	3,115,374
3	0	0	100	0	0	0	0	0	0	0	0	100
4	444,235	13,416,909	0	25,219,090	4,587,512	0	27,465	10,009	0	79,822	0	43,719,232
5	14,507	14,350,471	0	9,322,926	10,540,416	119,872	0	0	0	463	0	33,457,755
6	0	0	0	15,731	9,551	0	0	0	0	0	0	25,302
7	0	0	0	0	47,559	0	6,527,986	0	0	0	0	6,570,555
8	0	0	0	0	0	0	0	9,239,338	59,061	174,559	0	9,473,058
9	0	0	0	0	0	0	0	9,437,907	246,554	0	0	9,684,551
10	230,715	61,249,075	0	2,045,899	127,056	0	0	8,877,749	21,791,832	0	0	94,121,735
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	1,492,417	94,040,220	100	35,054,510	16,240,502	119,872	6,550,452	27,565,154	22,098,257	255,887	0	204,251,508

1970	1	2	3	4	5	6	7	8	9	10	11	SUM
1	920,847	1,788,459	0	155,380	655,117	0	0	0	0	0	0	3,539,828
2	0	7,011,258	0	0	0	0	0	0	0	137	0	7,011,400
3	0	0	0	0	0	0	0	0	0	0	0	0
4	755,729	17,185,956	0	25,834,623	4,277,970	0	9,452	0	0	39,993	0	47,983,723
5	30,149	18,608,298	0	5,304,131	10,445,501	0	13,370	0	0	519,547	0	35,000,068
6	0	0	0	9,710	7,107	0	2,015	0	0	0	0	19,712
7	0	0	0	0	0	0	7,064,458	0	0	0	0	7,064,458
8	0	35,054	0	0	0	0	0	11,314,250	81,622	53,241	0	11,484,177
9	0	30,050	0	0	0	0	0	9,357,525	505,712	0	0	9,893,288
10	560,039	53,589,001	0	2,070,545	182,521	0	0	9,216,484	29,087,991	0	0	93,567,571
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	1,722,764	93,257,077	0	33,554,407	15,569,576	0	7,090,095	29,888,258	29,675,325	611,913	0	210,489,417

1971	1	2	3	4	5	6	7	8	9	10	11	SUM
1	1,071,730	1,912,510	0	352,724	838,854	0	0	0	0	0	0	4,175,827
2	0	1,133,398	0	0	1,787	0	0	0	0	5,108	0	1,140,290
3	0	0	15,845	0	0	0	0	0	0	0	0	15,845
4	45,124	14,714,724	0	27,189,803	4,509,854	0	0	0	0	128,289	0	46,587,804
5	115,872	15,738,774	0	5,754,868	10,279,558	0	33,182	0	0	575	0	31,923,731
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	7,923,343	0	0	0	0	7,923,343
8	0	0	0	0	0	0	0	10,717,717	53,888	173,579	0	10,945,279
9	0	72,505	0	0	0	0	0	9,109,487	52,113	3,078	0	9,237,288
10	350,247	58,781,278	0	4,811,174	418,144	139	0	15,444,975	15,787,555	0	0	115,581,518
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	1,580,571	96,265,182	15,845	38,146,541	16,219,132	139	7,956,575	35,271,094	15,913,775	311,719	0	231,590,025

	1972						1972					
	7	8	9	10	11	SUM	1	2	3	4	5	6
1	0	0	0	17	0	5,087,808	1,585,456	2,171,240	0	1,310,792	820,181	0
2	0	0	0	22,780	0	6,300,458	0	5,125,170	0	0	0	0
3	0	0	0	0	0	7,355	0	0	7,355	0	0	0
4	9,877	0	0	20,524	0	88,403,896	124,201	8,298,310	0	25,154,647	5,785,884	0
5	15,051	42,607	0	417	0	41,157,226	26,195	6,406,816	0	3,011,601	17,600,530	0
6	0	0	0	0	0	20,286	0	0	0	0	0	20,286
7	7,785,197	0	0	0	0	7,785,197	0	0	0	0	0	0
8	0	10,800,823	17,507	174,464	0	10,897,804	0	0	0	0	0	0
9	0	8,355,950	140	0	0	9,760,802	0	1,151,810	0	0	41,771	0
10	0	19,554,410	40,443,314	0	0	143,450,152	675,221	76,550,150	0	4,774,805	1,101,974	0
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	7,811,000	30,143,000	40,476,060	417,002	0	247,550,074	2,302,071	101,117,770	7,355	36,351,205	20,549,531	20,286

	1973											
	1	2	3	4	5	6	7	8	9	10	11	SUM
1	1,126,551	2,001,534	0	1,013,200	807,144	0	0	0	2	41	0	[illegible],030,590
2	0	8,147,707	0	24,870	0	0	0	0	0	40	0	[illegible],172,614
3	0	0	477,000	0	0	17,120	0	0	0	0	0	494,200
4	24,853	5,037,100	0	20,440,153	6,271,134	0	15,635	0	26,610	10,935	0	32,593,567
5	65,140	2,440,292	0	4,475,032	11,741,204	0	110,082	0	20,827	0	0	18,910,487
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	4,805,780	0	0	0	0	4,805,780
8	0	0	0	0	0	0	0	10,513,157	63,807	285,810	0	10,862,177
9	0	1,250,301	0	63,020	210,601	0	0	7,571,886	0	183,055	0	9,316,573
10	1,260,853	91,260,727	70,567	23,140,601	6,559,761	0	0	31,130,466	41,[illegible],469	0	0	196,556,716
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	2,484,707	110,040,040	556,567	51,215,171	25,670,000	17,120	4,228,387	49,223,424	41,263,000	420,067	0	297,000,206

	1974											
	1	2	3	4	5	6	7	8	9	10	11	SUM
1	816,405	1,201,101	0	1,171,201	1,200,210	0	0	0	0	130,732	0	[illegible],190,515
2	0	10,501,547	0	87,015	15,440	0	0	0	10,111	0	0	10,647,111
3	0	0	24,406	0	0	0	0	0	0	0	0	24,406
4	67,315	6,000,150	0	[illegible],500,855	5,114,216	8,145	21,511	90,841	[illegible],641	0	0	[illegible]
5	50,077	1,545,717	0	4,197,947	9,412,950	247,546	153,192	15,510	0	460	0	[illegible],174,819
6	0	0	0	0	124,941	106,092	15,114	0	0	0	0	[illegible]
7	0	0	0	[illegible]	[illegible],001	0	241,190	0	0	0	0	[illegible]
8	0	0	0	0	0	0	0	10,419,984	17,074	0	0	[illegible]
9	0	185,000	0	51,117	0	0	0	7,124,211	201,008	10	0	[illegible]
10	2,081,945	81,266,450	0	[illegible]	11,240,451	0	0	11,101,156	41,084,508	0	0	[illegible]
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	[illegible]	[illegible]	24,406	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]

1975	1	2	3	4	5	6	7	8	9	10	11	SUM
1	440,155	1,071,170	0	2,581,570	2,403,400	96,307	81,077	0	0	0	0	6,695,554
2	0	11,469,606	0	722,877	107,577	0	0	0	0	10	0	11,990,160
3	0	0	51,700	0	0	0	0	0	0	0	0	51,700
4	95,510	3,970,157	0	17,369,307	5,503,351	0	3,950	0	75	0	0	26,502,547
5	72,571	154,754	0	3,950,500	10,506,200	0	351,646	0	0	0	0	15,133,960
6	0	0	0	0	71,832	37,216	30,440	0	0	0	0	93,496
7	0	0	0	0	3,950	55,232	324,037	0	0	0	0	395,121
8	0	0	0	0	0	0	0	9,860,945	44,330	0	0	9,905,293
9	0	14,320	0	33,501	0	0	0	5,750,750	341,041	0	0	7,109,710
10	5,991,110	90,692,097	0	52,097,410	30,150,654	0	0	33,130,914	44,901,941	0	0	255,963,033
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	7,449,462	105,471,009	51,700	75,185,527	49,045,747	190,750	796,862	49,742,627	45,287,295	10	0	333,799,595

1976	1	2	3	4	5	6	7	8	9	10	11	SUM
1	1,217,235	310,559	0	1,527,029	2,415,370	100,505	58,915	0	232,503	0	0	5,952,207
2	0	12,474,701	0	0	98,995	0	0	0	0	107,740	0	12,753,517
3	0	0	169,431	0	0	2,702	0	0	0	0	0	171,133
4	72,702	2,070,856	0	16,504,594	4,976,730	91,570	15,367	82,133	0	2,150	0	24,089,200
5	50,597	45,353	0	2,013,070	9,770,129	552,172	705,906	0	0	0	0	12,500,145
6	0	0	0	15,006	0	19,945	100,345	0	0	0	0	136,376
7	0	0	0	0	0	0	2,709	0	0	0	0	2,709
8	0	0	0	0	0	0	0	11,970,030	37,796	0	0	12,008,726
9	692	30,306	0	0	0	0	0	5,575,713	496,703	0	0	7,112,004
10	10,051,200	94,700,275	50,512	95,001,714	40,701,021	0	0	47,511,495	49,796,317	0	0	337,201,434
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	11,410,505	110,537,230	237,043	135,343,301	55,503,045	757,003	883,202	65,240,271	50,554,009	104,009	0	413,751,509

1977	1	2	3	4	5	6	7	8	9	10	11	SUM
1	976,330	187,910	0	1,397,370	2,766,459	64,400	0	0	113,917	17	0	5,501,751
2	17,195	13,975,383	0	0	8,004	0	0	0	0	200,333	0	14,155,906
3	0	0	17,557	0	0	0	0	0	0	0	0	32,452
4	55,350	1,725,307	0	17,253,853	4,371,900	22,714	19,207	0	5	53,317	0	23,511,265
5	40,441	2,792	0	2,009,590	7,450,771	574,455	257,905	0	0	0	0	10,304,914
6	0	0	0	2,920	11,751	10,111	80,403	0	0	0	0	110,275
7	0	0	0	0	0	40,777	0	0	0	0	0	40,777
8	0	0	0	0	0	0	0	13,117,371	31,910	0	0	13,144,251
9	0	181,017	0	0	95,710	0	0	14,117,330	537,140	1,710,777	0	16,551,946
10	10,511,044	91,369,512	6,985	110,919,059	78,557,877	0	0	57,000,241	45,615,577	0	0	305,119,377
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	11,777,100	109,185,501	17,557	110,587,729	93,304,770	661,059	165,606	85,137,901	46,300,669	1,964,004	0	480,577,514

CONDENSED2014

DISTILLATE FUEL OIL

1969	1	2	3	4	5	6	7	8	9	10	11	SUM
1	705,375	458,717	0	21,500	8,878	0	0	0	0	4,264	0	1,189,936
2	134,253	12,012,345	9,941	1,040	0	0	0	0	0	9,335	0	12,167,924
3	0	44,564	1,951,501	0	0	251,222	0	0	0	0	0	2,259,309
4	2,716,575	13,974,667	1,291	2,287,571	281,228	297,155	179,440	147,916	15,245	6,455	0	19,872,593
5	686,805	4,030,604	0	955,110	888,347	378,256	486,447	0	0	21,449	0	8,150,186
6	0	0	179,757	53,741	61,491	1,864,326	179,532	0	0	47	0	2,338,999
7	0	0	0	55,170	56,658	25,799	680,670	0	0	0	0	826,705
8	0	0	0	51,156	0	0	0	8,516,065	988,107	18,228	0	9,558,556
9	11,433	796,504	0	0	0	0	0	86,035	533,100	773,278	0	2,101,320
10	45,001	1,240,998	43,299	12,391	199,287	0	0	12,507	12,406	0	0	1,581,969
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	4,210,882	53,350,499	2,187,788	3,438,555	1,495,081	3,088,759	1,484,156	8,770,333	1,561,816	835,040	0	80,767,867

1970	1	2	3	4	5	6	7	8	9	10	11	SUM
1	711,522	547,884	0	24,597	14,542	0	4,170	0	0	1,345	0	1,302,780
2	170,305	20,556,754	11,245	50,826	27,870	0	0	0	0	115	0	20,782,515
3	0	40,302	2,086,411	6,375	0	104,077	0	0	0	0	0	2,165,965
4	1,017,954	15,503,464	2,466	2,055,888	175,525	251,888	190,807	4,001	1	854	0	21,507,858
5	520,174	4,500,760	0	552,505	986,202	234,910	492,113	5,022	0	163	0	7,401,555
6	0	0	194,449	0	57,961	2,341,551	151,021	0	0	0	7,701	2,754,775
7	0	0	0	4,556	55,326	75,080	554,451	0	0	0	0	798,422
8	0	22,515	0	0	500	0	0	7,802,807	880,609	2,547	0	8,726,338
9	0	1,858,229	0	40,215	12,103	0	0	116,664	620,585	305,477	0	2,951,273
10	87,402	1,865,403	0	11,451	135,562	0	0	61,210	20,411	0	0	2,180,026
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	4,571,357	52,982,430	2,214,571	2,762,343	1,557,966	3,219,533	1,400,764	8,000,074	1,459,570	300,971	7,701	70,768,177

1971	1	2	3	4	5	6	7	8	9	10	11	SUM
1	549,510	666,157	0	20,927	30,224	30,081	153,837	0	0	23,611	0	1,492,217
2	156,527	31,554,811	4,585	8,191	19,525	0	0	0	0	215	0	31,753,150
3	0	14,000	2,123,442	0	0	268,805	0	0	0	0	0	2,406,345
4	1,325,011	14,621,190	0	1,067,755	551,005	394,875	211,730	17,454	42	21,714	0	21,153,050
5	617,031	4,321,170	0	511,750	2,270,787	157,300	550,719	31,111	0	100	0	7,406,135
6	1,229	0	235,669	94,710	70,499	1,044,570	137,051	0	0	0	0	2,306,140
7	0	0	0	17,272	32,450	97,226	855,000	0	0	0	0	1,013,442
8	0	10,234	0	0	0	0	0	5,216,095	405,391	74,682	0	5,235,103
9	95,973	2,558,927	0	25,715	0	0	0	60,965	786,104	110,330	0	3,639,004
10	555,467	4,271,443	0	10,439	154,510	0	0	100,517	161,790	0	0	5,253,600
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	5,299,748	58,020,230	2,363,707	2,584,100	2,430,130	2,081,517	1,951,227	7,865,062	1,552,040	310,741	0	84,170,105

1972

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	645,687	458,976	0	49,411	53,111	5,419	333,419	0	0	7,648	0	1,448,872
2	75,447	32,959,309	4,370	189,635	1,788	0	0	0	0	1,791	0	33,232,340
3	0	15,210	2,313,374	0	0	276,575	0	0	0	0	0	2,605,159
4	1,571,117	15,238,871	0	2,248,316	812,898	512,552	251,658	0	130	80	0	22,634,831
5	689,957	4,467,897	0	175,214	1,328,499	126,884	308,529	0	0	26,659	0	7,718,474
6	0	0	141,189	0	58,445	1,973,183	218,667	0	0	0	0	2,325,485
7	0	0	0	49,282	38,759	97,163	1,879,471	0	0	0	0	2,055,675
8	0	0	0	0	0	0	0	8,178,187	664,827	41,819	0	8,883,951
9	45,833	3,598,277	0	0	0	0	0	52,889	884,158	47,181	0	4,628,538
10	714,538	15,948,791	0	15,776	682,384	0	0	149,118	25,776	0	0	17,456,883
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	5,742,789	72,674,836	2,458,933	2,928,636	2,988,877	2,991,596	3,274,741	8,380,114	1,573,599	128,187	0	103,825,218

1973

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	897,447	57,800	0	138,556	67,812	0	171,280	0	91	7,661	0	1,332,965
2	252,750	32,808,940	54,341	33,616	1,641	0	0	0	0	37,622	0	33,250,910
3	0	0	1,917,566	0	0	170,854	0	0	0	0	0	2,088,420
4	4,855,890	11,275,572	0	1,280,417	1,801,991	97,116	235,867	28,681	77	310,750	0	20,401,969
5	601,687	2,880,720	0	577,820	2,220,872	183,495	977,421	13,215	0	0	0	7,347,459
6	0	0	75,283	0	28,526	2,335,139	236,770	0	0	0	0	2,726,647
7	0	0	0	8,236	15,510	10,887	2,886,447	0	0	0	0	2,878,875
8	0	0	0	768	0	0	0	8,351,720	417,392	28,997	0	8,818,769
9	280,697	4,751,436	0	558,994	81,425	0	0	169,554	1,171,271	218,786	0	7,245,883
10	790,250	25,467,510	0	791,409	2,433,526	0	0	608,730	137,887	0	0	30,311,492
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	6,977,867	77,253,891	2,049,110	5,330,592	6,812,605	2,737,606	3,626,925	9,271,080	1,747,180	604,736	0	115,587,817

1974

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	1,350,310	165,270	0	53,987	59,584	0	40,406	0	0	1,365	0	1,669,575
2	149,155	15,584,795	91,775	107,770	58,510	0	0	13,175	0	7,757	0	16,019,687
3	0	0	1,790,500	1,743	0	115,297	0	0	0	0	0	1,915,139
4	3,745,085	8,388,865	0	4,587,852	986,586	86,785	152,536	170,703	45,760	15,550	0	19,898,579
5	801,109	2,470,314	0	553,634	2,376,153	82,847	1,817,770	13,206	0	31	0	7,774,149
6	0	0	94,331	117,726	84,316	2,157,310	457,655	0	0	0	0	2,921,358
7	0	0	0	19,465	15,450	76,730	2,222,474	0	0	0	0	2,360,096
8	0	25,717	0	25,737	0	0	0	5,897,745	177,200	24,700	0	6,500,976
9	199,867	4,205,251	0	146,807	0	0	0	170,811	1,867,811	57,777	0	6,852,536
10	447,465	9,487,971	20,800	447,253	133,864	0	0	664,707	665,977	0	0	11,958,606
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	6,692,977	41,119,487	2,004,709	6,158,570	3,906,519	2,579,953	3,893,071	7,356,834	2,881,994	103,833	0	95,750,676

	1975											1975
	1	2	3	4	5	6	7	8	9	10	11	SUM
1	2,089,246	149,077	0	62,860	28,257	0	61,987	0	0	351	0	2,112,591
2	155,057	32,016,455	15,250	60,635	0	0	0	0	71	10,001	0	33,000,210
3	0	4,041	2,003,107	0	0	184,701	2,350	0	0	0	0	2,195,100
4	3,133,027	14,120,135	0	3,440,020	810,240	225,227	140,020	34,405	4,525	547	0	21,914,751
5	1,007,190	3,619,172	0	504,104	2,105,036	50,156	1,353,515	0	0	41,722	0	8,770,695
6	0	0	31,450	75,047	50,556	1,010,605	540,311	0	0	0	0	2,503,969
7	0	0	0	454	10,594	94,050	2,150,006	0	0	0	0	2,765,494
8	0	10	0	0	0	0	0	8,101,601	437,076	5,620	0	8,625,174
9	210,600	4,260,040	0	0	0	0	0	240,001	1,147,202	23,470	0	5,007,510
10	83,973	4,305,537	0	430,019	130,682	0	0	155,403	465,030	0	0	5,601,433
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	6,589,701	59,303,104	2,050,007	4,551,055	3,260,160	2,401,639	4,250,007	8,621,500	2,055,653	101,730	0	93,373,776

	1976											1976
	1	2	3	4	5	6	7	8	9	10	11	SUM
1	2,312,353	86,430	0	98,686	150,300	22,391	130,221	0	64	985	0	2,819,287
2	214,087	32,062,201	22,706	54,010	0	0	0	47	0	298	0	33,318,471
3	0	0	2,050,944	0	0	310,002	0	0	0	0	0	2,300,936
4	3,403,225	12,016,525	0	2,304,104	941,157	261,150	104,155	68,530	7	154	0	19,170,282
5	790,025	2,043,205	0	855,145	1,202,557	107,103	1,607,613	0	0	0	0	9,100,456
6	0	0	17,173	255,501	58,216	2,094,645	530,930	0	0	0	0	2,986,055
7	0	0	0	5,286	52,150	44,220	2,204,000	0	0	0	0	2,297,042
8	0	20	0	17,070	0	0	0	9,052,591	157,007	10,356	0	9,457,024
9	524,010	5,000,036	0	0	7,015	0	0	344,241	1,455,150	10,012	0	7,042,592
10	92,053	2,126,067	2,602	520,215	13,426	0	0	162	405,520	0	0	3,170,371
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	7,345,201	55,525,373	2,170,505	3,701,307	4,525,170	2,044,500	4,083,017	9,475,771	2,237,936	22,525	0	92,741,390

	1977											1977
	1	2	3	4	5	6	7	8	9	10	11	SUM
1	2,159,789	194,042	0	123,576	107,316	0	27,366	0	194	325	0	2,624,500
2	251,000	32,735,277	82,400	100,701	54,213	0	0	0	16	253	0	33,315,916
3	0	0	1,450,153	0	0	230,529	0	0	0	0	0	1,690,682
4	3,664,652	11,174,776	0	3,500,256	801,220	40,279	541,552	101,314	6,500	449	0	19,913,187
5	645,304	3,106,303	0	1,007,314	3,612,252	191,500	2,119,456	0	0	177	0	10,802,906
6	0	0	52,602	0	44,172	2,253,011	420,044	0	0	0	0	2,771,729
7	0	0	0	1,700	55,410	84,161	2,121,019	0	0	0	0	2,263,149
8	41,157	290,246	0	43,512	12,401	0	0	8,031,252	229,017	20	0	8,740,246
9	845,749	5,307,550	0	0	0	0	0	260,116	1,104,561	10,641	0	7,620,617
10	264,103	6,250,031	0	70,714	22,410	0	0	244,216	192,064	0	0	7,140,641
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	7,091,022	50,559,155	1,595,243	6,257,021	4,011,590	2,809,451	5,233,143	8,637,500	1,708,333	12,135	0	93,516,664

RESIDUAL FUEL OIL

CONDENSED2915

	1969											1969
	1	2	3	4	5	6	7	8	9	10	11	SUM
1	4,238,685	119,517	0	48,717	59,705	0	0	0	49	1,083	0	4,580,591
2	440,370	35,420,733	31,511	18,190	78,370	0	0	281	157	189,414	0	36,067,072
3	0	6,400	1,800,176	0	0	255,791	0	0	0	0	0	1,951,487
4	1,470,577	3,102,071	4,430	1,887,183	680,445	651,037	157,916	20,870	12,747	515,840	0	8,758,420
5	143,487	400,718	47,711	661,000	791,417	187,825	30,404	0	201	260,845	0	2,819,580
6	0	0	492,777	25,135	0	817,716	33,714	0	0	0	0	1,370,330
7	0	0	15,749	71,013	70,416	755,307	717,951	0	0	0	0	1,640,746
8	0		0	0	0	0	0	7,074,749	1,181,562	1,705,955	0	9,963,266
9	0	0	0	240	121	0	0	410,190	530,795	28,724	0	1,107,061
10	11,245,402	62,929,077	224	570,493	500,753	0	0	155,170	760,797	0	0	76,571,370
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	17,430,044	102,550,102	1,677,552	3,280,051	2,251,577	2,658,667	939,085	7,090,460	2,615,180	2,701,990	0	144,041,079

	1970											1970
	1	2	3	4	5	6	7	8	9	10	11	SUM
1	5,566,922	47,697	0	189,871	387,560	10,190	0	0	240	24,185	0	6,070,031
2	354,087	39,533,987	34,500	15,085	55,458	0	0	211	479	159,517	0	40,204,055
3	0	4,258	1,199,610	0	0	599,076	0	0	0	0	0	1,903,846
4	1,174,581	3,176,099	2,132	2,045,000	957,001	915,106	165,490	0	0	552,230	0	9,551,424
5	257,174	746,006	0	795,571	731,521	459,140	171,077	0	0	150,001	0	3,252,965
6	0	0	110,352	12,730	74,300	702,420	45,657	0	0	0	0	1,145,467
7	0	0	1,810	450	7,736	150,371	704,000	0	0	0	0	867,085
8	0	49,175	0	0	0	0	0	6,122,234	1,275,064	2,097,404	0	9,544,067
9	412,375	7,904,185	0	0	0	0	0	276,000	904,213	342,051	0	9,839,085
10	17,951,492	72,085,242	0	670,345	717,473	0	0	319,271	323,682	0	0	92,077,510
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	26,716,046	124,548,046	1,547,670	4,429,411	2,745,056	2,065,294	1,017,036	6,710,500	2,504,685	3,336,363	0	170,545,576

	1971											1971
	1	2	3	4	5	6	7	8	9	10	11	SUM
1	5,669,895	0	0	371,815	580,111	117,971	0	0	0	6,739	0	6,710,055
2	419,870	42,873,240	8,876	187,077	84,566	0	0	215	0	67,794	0	43,450,040
3	0	2,547	1,297,991	0	0	704,180	0	0	0	0	0	2,004,742
4	1,379,645	2,203,744	0	1,752,044	1,115,901	441,187	342,640	0	0	405,717	0	8,141,577
5	250,020	1,011,641	0	1,138,740	1,100,425	1,254,011	177,017	0	0	189,152	0	5,229,181
6	0	0	204,600	78,817	19,400	504,146	18,251	0	0	0	0	869,474
7	0	0	0	4,677	27,926	99,145	581,049	0	0	0	0	633,192
8	0	0	0	0	0	0	0	8,752,874	1,351,057	1,315,107	0	11,400,709
9	402,579	10,414,044	0	85,504	19,711	0	0	410,766	1,400,055	412,353	0	13,105,092
10	13,111,147	64,783,540	9,530	626,807	1,010,617	0	0	[illegible]	312,706	0	0	[illegible]
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	21,134,434	120,971,670	1,520,895	4,051,570	4,104,555	3,711,601	[illegible]	10,410,571	2,855,600	[illegible]	0	172,810,447

1972												
	1	2	3	4	5	6	7	8	9	10	11	SUM
1	8,728,455	6,572	0	515,153	102,646	51,324	21,547	0	0	28,102	0	9,466,110
2	327,332	46,545,005	19,754	101,001	26,574	0	0	821	81,721	334,160	0	47,416,250
3	0	0	1,670,802	0	0	875,190	1,300	0	0	0	0	2,496,582
4	1,402,295	3,731,354	0	1,003,241	1,751,734	755,024	394,175	0	1	408,449	0	10,187,006
5	237,203	1,263,457	0	1,357,051	1,615,086	1,626,241	215,117	0	0	139,044	0	6,454,215
6	0	0	160,574	20,210	15,962	700,201	104,975	0	0	0	0	1,290,090
7	525	0	0	2,742	9,000	143,520	581,074	0	0	0	0	737,671
8	0	23	0	0	0	0	0	7,948,700	1,403,900	806,030	0	10,179,640
9	329,725	14,490,120	0	27,701	28,153	0	0	910,730	706,911	225,099	0	16,721,260
10	10,356,331	55,016,975	17,735	151,562	690,447	0	0	1,172,176	400,466	0	0	76,101,692
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	20,471,960	120,550,525	2,025,205	4,456,002	4,241,102	4,241,599	1,370,104	10,012,137	2,760,000	2,022,300	0	101,141,421

1973												
	1	2	3	4	5	6	7	8	9	10	11	SUM
1	10,570,150	0	0	433,030	571,250	32,371	9,342	0	471	10,007	0	11,636,206
2	375,003	50,127,095	17,075	155,225	14,030	0	0	250	20,505	919	0	50,712,930
3	0	0	2,297,107	0	0	637,005	0	0	0	0	0	2,935,002
4	1,416,900	2,322,594	1,373	2,037,605	2,091,717	011,744	751,170	00,053	0	237,509	0	11,351,550
5	217,165	440,003	0	405,667	2,067,303	1,664,097	775,040	0	0	45,050	0	5,565,517
6	0	0	153,075	4,014	50,416	701,110	17,031	0	0	0	0	1,146,075
7	0	0	0	0	1,375	40,505	370,045	0	0	0	0	370,016
8	0	140	0	0	0	0	0	9,601,007	1,160,540	1,009,162	0	11,040,053
9	1,151,742	12,020,021	0	003	9,296	0	0	1,350,574	504,774	497,140	0	15,530,490
10	20,220,001	50,130,507	21,173	2,230,501	1,202,050	0	0	2,134,215	440,073	0	0	06,406,610
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	33,950,067	125,040,530	2,700,594	6,070,743	6,006,453	3,005,701	1,032,347	11,265,012	2,325,320	1,001,603	0	190,704,340

1974												
	1	2	3	4	5	6	7	8	9	10	11	SUM
1	9,329,107	22	0	40,294	301,144	0	24,345	0	220	217	0	9,793,350
2	400,911	44,326,711	11,413	12,103	81,517	0	0	520	14,992	1,904	0	44,900,170
3	0	5,135	1,905,207	0	0	511,837	0	0	0	0	0	2,422,179
4	1,050,131	4,735,160	1,147	3,170,177	3,075,604	1,000,017	077,017	11,066	20,520	57,100	0	14,073,242
5	526,057	077,070	0	1,010,205	3,105,025	1,573,234	1,020,053	1,597	44,707	0	0	0,590,170
6	0	0	424,710	72,944	175,872	503,595	150,005	0	0	0	0	1,430,535
7	0	0	0	42,172	19,615	66,000	750,597	0	0	0	0	007,472
8	0	22	0	0	0	0	0	0,934,903	1,355,777	719,743	0	11,009,900
9	2,591,644	13,203,566	0	292,240	102,502	0	0	1,525,251	1,259,345	11,577	0	19,736,279
10	17,076,305	57,502,991	0	951,051	1,102,278	0	0	2,640,005	1,000,110	0	0	00,373,432
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	31,052,175	120,771,505	2,342,105	5,640,701	9,216,440	3,746,571	3,232,210	11,240,230	3,715,217	790,065	0	193,566,777

1975	1	2	3	4	5	6	7	8	9	10	11	SUM
1	9,900,693	493,520	0	100,145	176,290	43,576	22,517	0	1	525	0	10,813,357
2	221,777	41,774,104	0	10,050	60,017	0	0	152	0	215	0	42,087,740
3	0	0	1,657,419	0	55,412	602,175	5,142	0	0	0	0	2,400,140
4	7,007,125	5,151,677	0	1,096,250	3,200,357	910,105	795,650	190,500	60,970	43,070	0	16,390,351
5	1,100,000	1,010,500	0	530,633	1,155,776	1,100,600	657,460	0	0	101	0	5,567,437
6	0	0	103,231	93,530	206,002	500,075	410,202	0	0	0	0	1,590,930
7	0	0	0	0	63,047	60,030	1,137,225	0	0	0	0	1,260,911
8	186,971	170,205	0	25,352	0	0	0	10,511,105	994,596	1,357,210	0	13,354,070
9	2,550,337	11,030,271	0	32,026	143,770	0	0	1,051,621	1,302,934	0	0	17,020,250
10	12,050,244	41,061,000	6,350	500,624	676,367	0	0	2,005,271	1,320,011	0	0	58,050,570
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	20,300,045	102,250,414	1,047,012	4,510,707	9,017,010	3,332,434	3,031,006	15,577,730	3,597,421	1,401,063	0	172,092,500

1976	1	2	3	4	5	6	7	8	9	10	11	SUM
1	9,196,915	51,940	0	70,591	1,865,972	17,504	9,520	0	175,173	34,093	0	10,572,613
2	345,790	48,835,231	0	10,220	231,000	0	0	119,975	7	226	0	49,344,773
3	0	0	2,107,870	0	20,810	587,541	0	0	0	0	0	2,803,429
4	2,742,359	5,479,500	0	3,920,329	8,060,392	604,405	502,751	453,750	133,921	1,324	0	10,936,019
5	1,194,413	2,167,705	7,457	1,003,363	5,219,100	901,135	625,370	0	0	0	0	11,227,724
6	0	0	252,923	80,395	147,930	557,315	837,550	0	0	0	0	1,790,014
7	0	0	0	12,053	65,113	77,130	1,401,721	0	0	0	0	1,522,017
8	72,720	407,119	0	54,249	53,473	0	0	11,992,710	1,030,343	547,045	0	15,151,065
9	3,253,539	10,946,407	0	0	0	0	0	1,493,974	1,203,851	20,420	0	16,926,204
10	14,700,720	40,405,750	39,272	353,570	351,145	0	0	540,153	1,431,920	0	0	65,931,447
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	31,524,497	115,921,424	2,406,722	5,520,770	11,425,504	2,050,117	3,055,922	15,700,016	3,934,121	517,715	0	195,212,009

1977	1	2	3	4	5	6	7	8	9	10	11	SUM
1	9,377,355	470,240	0	303,903	1,066,740	19,119	53,771	0	0	25,314	0	10,273,450
2	100,254	45,707,601	0	110,923	247,100	0	0	90,076	5,541	182	0	46,000,717
3	0	0	3,369,993	0	0	630,700	0	0	0	0	0	3,999,703
4	5,434,105	7,343,925	0	5,444,333	4,062,700	304,110	471,767	170,735	192,137	13	0	24,191,747
5	1,496,501	3,247,732	0	1,947,511	9,554,092	942,570	1,260,590	37,995	60,676	0	0	17,443,545
6	0	0	252,510	45,740	200,365	905,423	400,473	0	0	0	0	1,003,560
7	0	0	0	44,525	71,932	111,349	1,200,419	0	0	0	0	1,455,225
8	50,956	135,100	0	14,522	0	0	0	14,417,105	1,030,543	276,227	0	15,924,733
9	3,144,155	7,511,501	0	59,553	0	0	0	1,552,700	1,962,523	1	0	14,340,135
10	12,173,951	50,900,526	10,000	190,501	11,537	0	0	1,740,000	1,254,740	0	0	66,270,447
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	31,135,270	115,407,705	3,670,507	9,566,001	15,015,065	2,913,106	3,407,650	17,570,150	4,506,260	302,730	0	203,500,349

CONDENSED2011

GASOLINE, INCLUDING NATURAL GASOLINE

	1969											1969
	1	2	3	4	5	6	7	8	9	10	11	SUM
1	1,735,557	58,478	0	64,201	291,719	0	591,240	0	649	23,926	0	2,755,821
2	368,703	25,101,601	34,303	15,066	0	0	0	0	497	1,327	0	25,562,297
3	0	54,172	2,620,394	0	0	112,147	0	0	0	0	0	2,786,713
4	9,151,137	7,351,579	0	2,395,507	1,303,303	898,714	688,052	188,525	29,067	134,379	0	22,211,344
5	2,689,631	1,660,379	0	988,320	2,698,019	1,125,139	3,419,599	70,082	15,092	13,378	1,920	12,492,457
6	0	0	176,308	58,995	176,410	3,235,320	381,142	0	0	0	0	3,948,471
7	0	1,152	0	54,506	219,371	325,771	4,769,233	0	0	0	0	5,169,123
8	0	760	0	0	0	0	0	6,610,631	720,865	17,807	0	7,350,012
9	669,390	1,975,691	0	24,869	0	0	0	101,787	221,945	17,578	0	3,007,220
10	14,882	60,892	0	0	0	0	0	99,496	260,805	0	0	442,955
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	14,620,480	35,320,734	2,830,885	3,482,344	4,749,989	5,699,890	9,759,425	7,167,822	1,247,160	208,395	1,920	86,814,581

	1970											1970
	1	2	3	4	5	6	7	8	9	10	11	SUM
1	1,566,207	54,594	0	21,646	170,303	0	514,175	0	1,256	1,177	0	2,329,458
2	374,833	23,863,210	37,259	20	0	0	0	0	425	3,252	0	24,279,497
3	0	17,274	2,496,995	0	0	87,343	0	0	0	71	0	2,601,673
4	9,807,854	10,326,657	854	2,071,616	1,587,566	978,272	723,615	37,530	2,860	74,059	0	25,622,899
5	3,037,350	1,773,012	0	361,313	2,594,216	999,437	3,706,840	0	0	146	0	12,451,324
6	0	0	231,867	34,344	110,050	3,706,993	573,569	0	0	0	0	4,654,823
7	0	0	0	63,801	215,240	417,741	5,065,819	0	0	0	0	5,762,641
8	0	58,502	0	0	32,237	0	0	7,174,219	792,377	2,235	0	8,059,570
9	529,254	2,175,591	0	0	7,717	0	0	130,931	139,339	13,409	0	3,076,271
10	25,786	170,677	0	6	0	0	0	52,259	240,214	0	0	504,972
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	15,341,292	38,547,525	2,737,665	2,552,786	4,615,420	6,188,786	10,594,010	7,414,977	1,244,491	114,367	0	99,331,336

	1971											1971
	1	2	3	4	5	6	7	8	9	10	11	SUM
1	2,058,391	56,236	0	7,577	105,887	44,900	402,953	0	2	1,451	0	[illegible]
2	392,926	25,493,253	44,260	103,312	0	0	0	96	0	1,207	0	[illegible]
3	0	7,666	2,513,425	0	0	45,971	0	0	0	[illegible]	0	[illegible]
4	10,692,977	12,411,153	960	2,405,528	2,169,865	1,557,152	963,801	159,612	3,914	139,524	0	[illegible]
5	2,160,614	1,070,204	0	435,529	2,483,212	1,041,880	3,224,554	0	0	142	0	[illegible]
6	0	0	161,240	19,286	93,144	3,944,957	541,775	0	0	0	0	[illegible]
7	0	0	0	84,959	277,947	381,164	[illegible]	0	0	0	0	[illegible]
8	0	[illegible]	0	0	26,420	0	0	[illegible]	[illegible]	[illegible]	0	[illegible]
9	[illegible]	[illegible]	0	15,104	0	0	0	[illegible]	[illegible]	[illegible]	0	[illegible]
10	0	[illegible]	0	0	11	0	0	[illegible]	[illegible]	0	0	[illegible]
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]

1972	1	2	3	4	5	6	7	8	9	10	11	SUM
1	2,970,552	112,385	0	48,320	159,762	10,497	291,519	0	4,534	1,643	0	3,599,221
2	302,097	27,144,231	36,215	32,419	216	0	0	0	20	1,920	0	27,537,119
3	0	1,952	2,123,144	0	0	71,615	0	0	0	26	0	2,196,737
4	10,717,899	11,110,981	0	2,300,463	1,434,629	826,564	839,331	215,687	4,488	28,170	0	27,478,228
5	2,279,277	2,291,058	0	229,964	2,839,875	863,791	3,163,262	0	0	166	0	11,667,393
6	0	0	125,663	5,351	58,698	3,631,864	685,638	0	0	25	0	4,499,231
7	0	0	0	66,272	246,893	310,263	5,346,512	0	0	0	0	5,969,940
8	0	1,765	0	0	3,861	0	0	6,291,896	820,970	1,421	0	7,127,121
9	825,252	2,334,782	0	21,847	0	0	0	283,585	217,689	36,996	0	3,630,251
10	0	230,125	0	0	0	0	0	4,408	251,589	0	0	486,202
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	17,085,080	43,227,279	2,285,022	2,704,636	4,735,126	5,714,594	10,326,261	6,715,756	1,307,306	70,375	0	94,171,435

1973	1	2	3	4	5	6	7	8	9	10	11	SUM
1	3,405,760	69,683	0	17,583	50,879	0	152,433	0	0	917	0	3,697,255
2	734,926	28,192,936	42,931	18,358	0	0	0	44	11,442	1,713	0	29,002,350
3	0	1,951	2,220,366	0	0	72,685	0	0	0	20	0	2,295,030
4	11,097,952	9,932,426	0	2,152,886	1,294,536	324,665	521,295	79,439	45,756	95,641	0	25,344,586
5	2,120,785	1,745,436	0	316,395	3,286,725	687,319	3,115,867	0	0	51,228	0	11,163,575
6	0	0	75,269	52,257	137,471	3,641,991	861,857	0	0	0	0	4,768,854
7	0	0	0	13,574	293,652	289,387	5,309,194	0	0	0	0	5,905,807
8	10,505	31,544	0	0	12,322	0	0	6,722,692	779,442	690	0	7,556,195
9	959,602	2,995,415	0	30,916	14,066	0	0	297,389	282,848	100,340	0	4,689,556
10	20,729	2,100,513	36	152,545	70,389	31	0	70,988	353,247	0	0	2,768,478
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	18,350,259	45,077,904	2,338,601	2,754,524	5,089,940	4,736,078	9,960,636	7,150,552	1,391,735	338,557	0	97,227,786

1974	1	2	3	4	5	6	7	8	9	10	11	SUM
1	3,295,024	149,519	0	37,142	76,543	159,464	143,858	0	0	1,581	0	3,863,047
2	886,135	28,274,357	45,413	22,498	1,054	0	0	76,029	0	576	0	29,382,035
3	0	0	1,519,659	0	0	49,892	0	0	0	0	0	1,569,551
4	10,741,709	8,173,905	4,123	2,393,937	1,547,743	70,234	378,103	35,965	45,873	43,587	0	[illegible]
5	2,199,780	1,762,067	0	475,647	2,923,330	246,533	2,020,063	185,872	22,049	17	0	[illegible]
6	0	0	10,484	29,441	111,066	3,494,497	1,125,155	0	0	0	0	[illegible]
7	0	0	0	0	164,162	290,543	5,451,362	0	0	0	0	[illegible]
8	0	214,518	0	0	14,156	0	0	5,891,482	604,041	20,604	0	[illegible]
9	1,824,549	3,172,891	0	147,265	77,152	0	0	249,229	[illegible]	9,841	0	[illegible]
10	333,298	3,036,561	10	693,116	96,892	19	0	140,646	344,312	0	0	[illegible]
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]

1975 1975

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	3,450,254	131,425	0	34,338	42,387	88,321	149,115	15,460	0	917	0	3,912,217
2	508,399	27,787,062	34,247	3,843	0	0	0	26,629	17	2,613	0	28,362,810
3	0	0	1,602,478	0	0	28,508	0	0	0	0	0	1,630,986
4	10,684,962	8,225,358	0	2,029,186	1,858,725	111,500	385,181	248,268	96,353	1,635	0	23,533,086
5	2,495,467	2,224,570	0	237,398	2,918,005	395,578	2,407,673	173,482	0	51	0	10,852,224
6	0	0	9,639	0	186,407	3,505,031	1,219,197	0	0	0	0	4,848,264
7	0	0	0	34,760	387,648	342,928	5,186,131	0	0	0	0	5,951,467
8	0	3,147	0	1,521	11,101	0	0	5,555,183	816,123	1,201	0	6,388,276
9	1,293,113	4,594,436	0	6	0	0	0	301,089	545,250	9,540	0	6,743,434
10	65,839	2,492,812	0	143,631	0	0	0	314,769	348,464	0	0	3,365,515
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	18,498,022	45,458,810	1,646,364	2,483,883	5,316,273	4,471,866	9,347,207	6,634,888	1,806,207	15,957	0	95,679,469

1976 1976

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	3,872,705	1,934	0	9,836	35,206	0	193,407	0	0	2,211	0	4,115,299
2	572,557	28,438,128	32,752	38,562	92,885	0	0	51,148	0	83	0	29,225,415
3	0	0	1,318,024	0	0	118,342	0	0	0	0	0	1,436,366
4	11,525,411	7,740,696	0	2,973,468	1,975,267	199,440	423,484	197,186	3	11,855	0	24,086,722
5	2,111,762	1,912,751	0	331,298	2,819,528	480,422	2,296,547	63,231	111,314	11	0	10,126,856
6	0	0	46,684	64,422	122,919	3,154,567	1,178,840	0	0	0	0	4,567,432
7	8,269	0	0	38,596	344,957	285,659	4,898,892	0	0	0	0	5,576,373
8	0	3,628	0	0	16,642	0	0	6,599,595	540,637	49	0	7,160,551
9	1,144,366	4,497,476	0	31,273	0	0	0	307,749	613,992	8,349	0	6,603,205
10	40,002	747,686	345	139,445	82,115	0	0	195,987	206,865	0	0	1,412,445
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	19,275,172	43,342,299	1,397,805	2,626,884	5,488,719	4,238,430	8,991,170	7,414,816	1,480,811	22,558	0	94,278,664

1977 1977

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	4,838,975	44,066	0	28,233	36,857	8,508	129,499	0	100	816	0	5,077,326
2	817,617	28,016,921	32,311	69,952	0	0	0	40	9,699	33,515	0	28,980,055
3	0	513	1,345,521	0	0	113,356	0	0	0	0	0	1,459,390
4	11,690,500	7,697,822	0	2,535,359	1,878,635	252,553	365,452	19,402	0	32,312	0	24,471,019
5	2,147,428	1,921,979	0	1,340,685	3,755,269	437,409	2,493,696	0	0	9	0	12,096,475
6	0	0	47,406	2,066	143,680	3,130,552	854,360	0	0	0	0	4,178,252
7	0	0	0	38,985	214,313	203,405	4,286,283	0	0	0	0	4,734,986
8	0	50,590	0	0	19,764	0	0	6,032,600	508,201	7,801	0	6,611,134
9	1,186,281	5,123,495	0	29,550	8,895	0	0	251,476	592,810	16,347	0	7,208,862
10	14,870	3,062,459	0	275,807	40,623	0	0	45,260	36,426	0	0	3,474,645
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	20,805,675	45,917,845	1,425,310	4,383,757	6,097,216	4,145,955	8,128,210	6,347,076	1,150,444	90,888	0	98,491,184

CONDENSED2912

JET FUEL

1969

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	789,600	13,752	0	0	0	0	0	29,408	0	0	0	832,760
2	29,730	4,104,335	10,027	0	0	0	0	0	0	0	0	4,144,092
3	0	9,265	276,589	0	0	0	0	0	0	0	0	285,854
4	1,972,757	1,227,447	0	230,134	36,907	209,599	34,227	222,290	125,035	0	0	4,058,396
5	584,490	120,327	0	103,207	375,334	20,487	185,326	50,308	33,776	0	0	1,473,265
6	0	0	0	2,092	0	49,873	0	0	0	0	0	51,965
7	0	0	0	0	1,387	19,438	470,025	0	0	0	0	490,860
8	0	0	0	0	0	0	0	2,215,132	296,354	0	0	2,511,486
9	29,351	26,446	0	0	0	0	0	4,514	508,374	0	0	568,685
10	0	0	0	0	0	0	0	0	104	0	0	104
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	3,405,728	5,501,572	286,616	335,323	413,628	299,517	689,578	2,521,652	963,643	0	0	14,417,457

1970

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	558,256	0	0	0	0	0	0	0	0	0	0	558,256
2	16,617	3,992,133	743	0	0	0	0	0	0	0	0	4,009,493
3	0	0	166,572	0	0	0	0	0	0	0	0	166,572
4	1,149,368	1,384,213	0	51,316	152,057	128,177	6,439	22,656	27,298	0	0	2,921,524
5	443,368	265,870	0	16,745	350,031	0	181,599	3,993	25,827	0	0	1,287,433
6	0	0	0	1,463	0	31,680	31,931	0	0	0	0	65,074
7	0	0	0	0	15,404	45,065	318,662	0	0	0	0	379,131
8	0	0	0	0	0	0	0	2,175,400	328,378	0	0	2,503,778
9	70,380	188,874	0	0	0	0	0	3,030	774,739	0	0	1,037,023
10	0	0	0	0	0	0	0	0	239	0	0	239
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	2,237,989	5,831,090	167,315	69,524	517,492	204,922	538,631	2,205,079	1,156,481	0	0	12,928,523

1971

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	809,499	24,939	0	13,175	1,415	0	1,568	0	0	0	0	850,596
2	0	4,452,515	1,305	0	0	0	0	0	0	0	0	4,453,820
3	0	13,370	300,903	0	0	0	0	0	0	0	0	314,273
4	1,485,388	1,552,083	0	67,984	43,754	97,067	19,087	0	69,228	0	0	3,334,591
5	382,078	355,709	0	66,510	390,619	12,953	234,649	0	3,818	0	0	1,446,336
6	0	0	0	0	0	39,040	32,981	0	0	0	0	72,021
7	0	0	0	0	7,660	168,902	359,339	0	0	0	0	535,901
8	0	0	0	0	0	0	0	1,252,593	248,517	0	0	1,501,110
9	196,007	239,667	0	0	0	0	0	17,355	720,391	0	0	1,173,420
10	0	0	0	0	0	0	0	0	81	0	0	81
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	2,872,972	6,638,283	302,208	147,669	443,448	317,962	647,624	1,269,948	1,042,035	0	0	13,682,149

1972	1	2	3	4	5	6	7	8	9	10	11	SUM
1	770,301	0	0	3,893	1,370	0	0	0	0	0	0	775,564
2	0	4,142,668	1,236	0	0	0	0	0	5,760	0	0	4,149,664
3	0	0	288,154	0	0	15,230	0	0	0	0	0	303,388
4	1,566,133	1,577,712	0	185,735	32,847	219,545	33,520	0	7,879	0	0	3,622,590
5	190,320	241,183	0	75,686	377,290	26,339	256,857	0	0	0	0	1,175,513
6	0	0	2,594	0	0	70,558	16,423	0	0	0	0	99,575
7	0	0	0	3,145	10,631	71,680	336,743	0	0	0	0	422,128
8	0	0	0	0	0	0	0	1,298,622	315,662	0	0	1,614,284
9	98,486	286,526	0	0	0	0	0	0	682,720	0	0	1,859,652
10	0	0	0	0	0	0	0	0	162	0	0	162
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	2,625,160	6,288,081	291,988	268,379	421,328	403,299	643,552	1,298,622	1,012,191	0	0	13,172,510

1973	1	2	3	4	5	6	7	8	9	10	11	SUM
1	772,370	7,199	0	938	0	0	0	0	0	0	0	780,415
2	15,172	4,833,053	11,546	0	0	0	0	0	0	0	0	4,859,771
3	0	0	188,102	0	0	0	0	0	0	0	0	188,102
4	1,199,415	1,565,661	0	160,427	26,376	59,162	40,767	0	0	0	0	3,050,888
5	401,156	257,484	0	22,282	397,975	50,783	309,823	0	0	0	0	1,519,513
6	0	0	0	0	0	52,855	3,889	0	0	0	0	55,864
7	0	0	0	9,476	37,687	152,817	286,223	0	0	0	0	486,203
8	0	0	0	10,515	0	0	0	1,329,545	140,685	0	0	1,480,745
9	170,495	315,242	0	0	25,911	0	0	28,854	535,546	0	0	1,077,048
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	2,646,526	6,179,639	199,648	211,538	487,949	315,517	647,822	1,358,399	676,231	0	0	12,715,469

1974	1	2	3	4	5	6	7	8	9	10	11	SUM
1	990,547	10,316	0	23,596	5,484	0	0	13,749	0	0	0	943,512
2	0	3,135,349	993	0	0	0	0	0	0	0	0	3,136,342
3	0	0	256,144	0	0	0	0	0	0	0	0	256,144
4	644,716	1,375,852	0	200,325	110,743	16,428	26,189	49,295	47,333	0	0	2,[illegible]01,655
5	358,152	246,794	0	25,194	301,546	50,884	298,893	0	27,223	0	0	1,[illegible]
6	0	0	0	11,046	8,910	70,878	12,598	0	0	0	0	110,[illegible]
7	0	0	0	23,664	5,986	101,999	351,556	0	0	0	0	[illegible]
8	0	0	0	0	0	0	0	941,101	247,250	0	0	1,[illegible]
9	26,989	71,813	0	0	0	0	0	55,270	143,838	0	0	[illegible]
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	1,920,324	4,[illegible],321	257,137	288,[illegible]1	320,473	335,112	[illegible]	999,[illegible]	[illegible]	0	0	13,[illegible]

1975

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	963,564	5,444	0	3,760	0	0	12,896	0	31,706	0	0	1,017,410
2	21,843	2,860,652	1,493	19	0	0	0	0	0	0	0	2,881,197
3	0	0	244,410	0	0	0	0	0	0	0	0	244,410
4	689,370	1,068,175	0	98,347	35,327	25,279	14,251	1,840	7,383	0	0	1,931,112
5	263,424	474,267	0	7,661	373,820	4,870	325,671	0	6,115	0	0	1,455,845
6	0	0	0	0	0	43,557	19,307	0	0	0	0	62,864
7	0	0	0	6,544	2,900	56,234	400,031	0	0	0	0	465,709
8	0	0	0	0	0	0	0	1,037,517	344,691	0	0	1,382,198
9	131,242	264,932	0	0	0	0	0	54,673	443,200	0	0	864,015
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	2,040,603	4,681,450	245,901	180,331	412,856	129,940	772,156	1,093,230	833,093	0	0	10,314,760

1976

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	1,153,583	19,862	0	0	0	0	0	0	32,471	0	0	1,205,916
2	15,680	2,511,938	859	0	0	0	0	0	0	0	0	2,529,477
3	0	0	256,667	0	0	2,860	0	0	0	0	0	259,527
4	1,155,459	1,543,515	0	131,278	121,445	105,326	10,700	113,444	43,959	0	0	3,225,127
5	347,186	496,440	0	12,440	396,984	29,556	337,344	130,349	0	0	0	1,770,299
6	0	0	0	2,900	0	58,506	11,324	0	0	0	0	72,730
7	0	0	0	0	28,476	131,001	343,678	0	0	0	0	503,155
8	10,881	0	0	0	0	0	0	1,024,588	510,174	0	0	1,545,643
9	67,099	126,172	0	0	0	0	0	30,613	438,515	0	0	662,419
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	2,749,888	4,697,928	257,526	166,618	546,905	327,249	703,046	1,299,014	1,025,119	0	0	11,773,293

1977

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	1,101,887	6,633	0	3,497	11,944	0	0	0	0	0	0	1,123,161
2	14,839	3,239,355	734	1,928	0	0	0	0	0	0	0	3,256,856
3	0	0	153,152	0	0	0	0	0	0	0	0	153,152
4	1,375,624	1,864,942	0	268,848	125,232	56,903	8,810	61,886	21,972	0	0	3,783,417
5	298,567	516,023	0	177,863	344,712	0	321,806	0	0	0	0	1,650,171
6	0	0	0	0	2,900	47,671	13,296	0	0	0	0	63,867
7	0	0	0	0	82,761	84,871	455,855	0	0	0	0	622,687
8	0	10,644	0	0	0	0	0	727,871	482,791	0	0	1,229,306
9	150,756	332,671	0	0	0	0	0	222	303,177	0	0	786,826
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	2,932,073	5,970,260	153,916	451,336	567,549	188,645	799,767	789,179	807,940	0	0	12,660,673

KEROSENE

1969

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	47,078	22,440	0	1,450	2,844	0	0	0	0	0	0	73,812
2	58,485	1,906,586	8,734	0	0	0	0	0	15	1,828	0	1,975,648
3	0	2,046	52,189	0	0	0	0	0	0	0	0	54,235
4	758,311	819,579	0	758,354	72,411	256,526	8,447	22,179	20	1,750	0	2,697,577
5	109,958	95,180	0	125,826	140,322	435,017	120,358	0	0	36,981	0	1,063,642
6	0	0	16,343	3,100	9,891	44,205	3,301	0	0	0	0	76,840
7	0	0	0	0	0	0	266,667	0	0	0	0	266,667
8	0	0	0	0	0	0	0	717,354	308,672	2,849	0	1,028,875
9	0	0	0	0	0	0	0	0	256,754	5,019	0	261,773
10	487,322	3,327,067	0	455,279	57,605	0	0	1,412,653	2,168,452	0	0	7,908,378
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	1,461,554	6,172,498	77,266	1,344,009	283,073	735,748	398,773	2,152,186	2,733,917	48,427	0	15,407,451

1970

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	52,521	8,650	0	2,303	5,721	0	0	0	0	18	0	69,213
2	41,060	1,647,453	1,699	0	0	0	0	0	0	1,305	0	1,691,517
3	0	3,474	58,657	0	0	0	0	0	0	0	0	62,131
4	761,083	925,342	11,200	454,886	66,975	356,928	13,574	37,582	0	1,056	0	2,628,626
5	515,126	213,082	0	164,139	83,171	366,826	119,639	0	0	9,192	0	1,471,175
6	0	0	5,469	0	1,901	57,782	5,521	0	0	0	0	70,673
7	0	0	0	0	14,078	9,945	322,840	0	0	0	0	346,863
8	0	0	0	298	0	0	0	320,893	236,710	330	0	558,231
9	5,040	157,106	0	0	0	0	0	675	179,289	8,560	0	350,670
10	670,030	4,076,469	0	476,557	69,399	65	0	1,361,866	2,028,141	0	0	8,682,527
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	2,044,860	7,031,576	77,025	1,098,183	241,245	791,546	461,574	1,721,016	2,444,140	20,461	0	15,931,626

1971

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	34,875	83,297	0	0	1,538	0	0	0	0	180	0	119,890
2	26,447	1,724,578	1,089	22	0	0	0	617	19	714	0	1,753,486
3	0	1,999	33,941	0	0	0	0	0	0	0	0	35,940
4	625,538	1,078,659	0	422,307	83,022	165,178	27,598	18,383	0	2,702	0	2,423,387
5	143,640	163,026	0	24,181	49,616	105,602	102,634	0	0	18,018	0	606,717
6	0	0	6,821	0	8,326	52,966	8,430	0	0	0	0	76,543
7	0	0	0	0	14,565	5,824	316,486	0	0	0	0	336,875
8	0	0	0	0	0	0	0	183,514	258,937	15	0	442,466
9	4,584	0	0	0	0	0	0	0	184,945	2,435	0	191,964
10	582,129	3,771,987	0	652,384	67,503	0	0	1,376,004	2,160,558	0	0	8,610,565
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	1,415,213	6,823,546	41,851	1,098,894	220,570	329,570	459,148	1,578,518	2,604,459	24,064	0	14,595,833

1972

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	151,982	17,721	0	0	0	0	0	0	0	253	0	169,956
2	32,743	2,257,643	942	1,292	0	0	0	0	3	883	0	2,293,466
3	0	0	31,690	0	0	0	0	0	0	0	0	31,690
4	534,635	889,110	0	334,486	41,575	95,052	25,817	5,798	0	2,023	0	1,928,496
5	234,371	58,412	0	17,657	27,376	68,213	104,705	0	0	7,117	0	517,851
6	0	0	0	0	2,487	7,229	4,709	0	0	0	0	14,425
7	0	0	0	9,515	0	6,853	307,629	0	0	0	0	323,997
8	0	0	0	0	0	0	0	351,351	219,345	21,049	0	591,705
9	0	82,119	0	0	0	0	0	0	172,929	1,258	0	256,306
10	742,399	4,342,965	0	643,230	52,920	18	0	1,207,181	1,949,887	0	0	8,938,600
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	1,696,130	7,647,970	32,592	1,006,180	124,358	177,365	442,860	1,564,330	2,342,124	32,583	0	15,066,492

1973

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	89,481	3,200	0	0	0	0	0	0	0	157	0	92,838
2	74,801	2,052,854	6,622	0	0	0	0	44	16	401	0	2,134,738
3	0	0	24,700	0	0	0	0	0	0	0	0	24,700
4	424,225	816,967	0	461,603	26,781	0	42,525	5,759	0	1,548	0	1,779,398
5	62,210	54,422	0	11,743	41,269	660	102,230	0	0	7,750	0	280,284
6	0	0	0	0	0	18,649	17,742	0	0	0	0	36,391
7	0	0	0	0	0	0	312,213	0	0	0	0	312,213
8	0	0	0	0	0	0	0	144,136	268,776	88,867	0	501,779
9	30,575	207,772	0	0	0	0	0	0	125,800	3,066	0	367,211
10	975,148	4,852,077	0	752,186	118,578	0	0	1,374,748	2,246,501	0	0	10,319,238
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	1,656,438	7,987,292	31,330	1,225,532	186,628	19,309	474,700	1,524,687	2,641,093	101,789	0	15,048,798

1974

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	18,618	0	0	0	0	0	17,155	0	24	115	0	35,912
2	62,921	1,719,784	16,980	3,732	0	0	0	63	3	1,120	0	1,804,607
3	0	0	54,859	0	0	0	0	0	0	0	0	54,859
4	320,748	793,141	0	199,469	18,378	0	20,782	0	0	610	0	1,354,378
5	207,810	158,556	0	1,699	52,962	8,340	99,741	0	0	521	0	501,879
6	0	0	0	0	0	10,415	13,719	0	0	0	0	24,134
7	0	0	0	0	981	755	193,583	0	0	0	0	195,319
8	0	0	0	0	0	0	0	130,759	287,344	71,781	0	489,884
9	11,179	227,121	0	14,586	0	0	0	12,083	128,008	3,949	0	396,926
10	661,312	5,977,899	0	[illegible]	88,860	0	0	873,291	2,183,578	0	0	[illegible]
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	[illegible]	[illegible]	71,839	538,671	153,581	19,710	355,980	1,016,196	2,598,961	78,096	0	12,962,023

						1975						
	1	2	3	4	5	6	7	8	9	10	11	SUM
1	15,947	50,245	0	0	0	0	0	0	0	51	0	66,243
2	68,891	1,314,900	5,369	0	0	0	0	0	48	741	0	1,389,940
3	0	0	49,235	0	0	0	0	0	0	0	0	49,235
4	254,151	782,436	0	237,197	15,452	9,315	31,100	3,201	0	393	0	1,333,325
5	60,725	125,446	0	19,773	9,446	3,875	86,062	0	0	380	0	304,907
6	0	0	0	0	0	25,934	21,633	0	0	0	0	47,567
7	0	0	0	0	0	0	122,142	0	0	0	0	122,142
8	0	0	0	992	0	0	0	135,485	302,961	36,554	0	475,992
9	19,594	155,004	0	0	0	0	0	0	150,294	1,636	0	326,528
10	269,784	1,895,457	0	101,891	3,846	0	0	561,378	1,800,922	0	0	4,631,618
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	688,093	4,324,806	54,604	359,842	27,944	37,324	261,137	700,064	2,254,225	39,753	0	8,746,282

						1976						
	1	2	3	4	5	6	7	8	9	10	11	SUM
1	25,238	0	0	0	4,031	0	0	0	1,907	83	0	31,259
2	54,911	1,519,241	7,271	0	0	0	0	25	0	525	0	1,581,973
3	0	0	18,138	0	0	0	0	0	0	94	0	18,232
4	255,318	582,638	0	363,641	145,711	26,196	24,442	7,401	0	9,708	0	1,415,147
5	38,128	153,744	0	11,142	1,571	0	72,663	0	0	58	0	277,306
6	0	0	4,136	0	0	8,634	19,527	0	0	0	0	32,297
7	0	0	0	0	0	4,228	97,127	0	0	0	0	101,355
8	0	0	0	0	0	0	0	85,220	194,215	5,545	0	284,980
9	78,205	486,153	0	0	0	0	0	0	51,212	1,417	0	616,987
10	248,415	1,199,252	0	0	71,951	0	0	207,276	1,317,894	0	0	3,044,788
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	700,215	3,941,028	29,545	374,783	223,266	39,058	213,959	299,918	1,567,220	17,500	0	7,406,512

						1977						
	1	2	3	4	5	6	7	8	9	10	11	SUM
1	35,073	0	0	14,221	46,110	0	0	0	0	177	0	95,591
2	46,837	1,746,450	8,542	0	0	0	0	0	14	779	0	1,802,6[illegible]
3	0	0	23,378	0	0	37,675	0	0	0	0	0	61,053
4	237,538	683,140	0	479,924	118,408	[illegible]	33,944	82,070	0	328	0	1,642,002
5	55,077	382,643	0	47,886	12,456	4,158	75,797	0	0	31	0	[illegible]
6	0	0	0	2,924	0	5,865	10,127	0	0	0	0	18,916
7	0	0	0	0	0	0	100,604	0	0	0	0	[illegible]
8	0	0	0	0	0	0	0	142,176	[illegible]	0	0	[illegible]
9	47,131	[illegible]	0	0	0	0	0	0	[illegible]	[illegible]	0	[illegible]
10	161,704	[illegible]	0	[illegible]	0	0	0	[illegible]	[illegible]	0	0	[illegible]
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]

CONDENSED1911

ORDNANCE AND ACCESSORIES

1969

	1	2	3	4	5			8	9	10	11	SUM
1	1,010	0	0	0	40	0	50	0	17	15	0	1,132
2	212	102	0	112	0	0	0	259	524	3,182	0	4,391
3	0	0	1,001	0	0	0	0	0	0	0	0	1,001
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	33	0	0	33
6	0	0	0	0	0	0	0	0	0	0	0	0
7	100	0	0	0	0	0	0	0	0	0	0	100
8	0	0	0	0	0	0	0	2,014	30	218	0	2,262
9	0	397	0	0	4	0	0	0	0	2	0	403
10	391	8,900	551	525	154	81	0	343	1,380	0	0	12,525
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	1,713	9,399	1,552	737	198	81	50	2,616	1,984	3,417	0	21,847

1970

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	250	0	0	0	0	0	0	0	125	11	0	386
2	35	134	0	107	0	0	0	20	102	3,016	0	3,414
3	0	0	744	0	0	0	0	0	0	2	0	746
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	37	5	0	42
6	0	0	0	0	0	0	0	0	0	0	0	0
7	50	0	0	0	0	0	0	0	0	0	0	50
8	0	0	0	0	0	0	0	2,473	35	151	0	2,570
9	20	321	0	0	0	0	0	0	0	399	0	740
10	211	6,072	184	729	43	42	0	238	586	0	0	8,605
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	1,066	6,527	928	836	43	42	0	2,731	886	3,594	0	16,653

1971

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	0	0	0	0	0	0	0	0	17	22	0	39
2	293	0	0	373	0	0	0	134	32	2,791	0	3,623
3	0	0	285	0	0	0	0	0	0	0	0	285
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	17	57	0	74
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	105	50	0	155
9	0	0	0	0	0	0	0	214	0	89	0	303
10	2,003	2,333	88	144	10	0	0	184	50	0	0	4,820
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	2,296	2,333	373	517	10	0	0	532	430	1,018	0	9,580

1972

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	0	0	0	0	0	0	0	0	23	13	0	36
2	158	597	0	182	0	0	0	1,095	48	3,925	0	6,005
3	0	0	135	0	0	0	0	0	0	0	0	135
4	0	388	0	0	0	0	0	0	0	0	0	388
5	0	0	0	0	0	0	0	0	0	191	0	191
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	2,172	0	0	0	0	0	0	259	119	0	2,550
9	0	55	0	0	0	0	0	29	0	555	0	639
10	3,689	2,513	61	139	181	34	0	139	357	0	0	7,113
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	3,857	5,537	196	441	181	34	0	1,264	597	4,803	0	17,110

1973

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	0	0	0	0	0	0	0	0	1,808	35	0	1,843
2	21	0	0	85	0	0	0	44	187	1,738	0	[illegible]
3	0	0	20	0	0	0	0	0	0	0	0	20
4	0	0	0	0	0	0	0	0	5	0	0	5
5	0	0	0	0	0	0	0	0	0	103	0	103
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	1,731	0	0	0	0	0	6	292	191	0	2,220
9	0	0	0	0	0	0	0	0	0	14	0	[illegible]
10	281	4,346	274	218	16	0	0	104	25	0	0	5,154
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	302	6,094	294	303	16	0	0	244	1,437	4,001	0	12,771

1974

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	0	700	0	0	0	0	0	0	15	152	0	867
2	2	2,073	0	52	0	0	0	4	44	6,277	0	8,457
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	60	0	60
6	0	0	0	0	0	0	0	0	0	6	0	6
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	57	0	0	0	0	0	0	340	455	0	852
9	0	0	0	0	0	0	0	0	0	2	0	2
10	355	1,909	9	140	24	1	0	200	12	0	0	2,650
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	357	4,738	9	192	24	1	0	200	420	6,912	0	12,912

1975

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	0	1	0	0	0	0	0	0	3	199	0	203
2	0	29	0	93	0	0	0	10	228	7,711	0	8,071
3	0	0	1,888	0	0	0	0	0	0	0	0	1,888
4	0	5	0	0	0	0	0	0	0	4	0	9
5	0	0	0	0	0	0	0	0	0	185	0	185
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	48	541	0	589
9	320	623	0	0	0	0	0	0	0	2	0	945
10	313	1,766	13	272	28	0	0	509	138	0	0	3,039
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	633	2,424	1,921	365	28	0	0	519	417	8,562	0	14,769

1976

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	0	10	0	0	0	0	0	0	42	370	0	422
2	0	195	0	533	0	0	0	18	739	4,392	0	5,877
3	0	0	15	0	0	0	0	0	0	0	0	15
4	0	0	0	0	0	0	0	0	0	7	0	7
5	0	0	0	0	0	0	0	0	0	11	0	11
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	18	557	0	575
9	586	885	0	0	0	0	0	4	0	1	0	1,476
10	200	1,342	7	35	16	1	0	239	4	0	0	1,844
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	786	2,432	22	568	16	1	0	261	803	5,338	0	10,227

1977

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	0	6	0	0	0	0	0	0	1	234	0	241
2	0	191	0	0	0	0	0	0	43	3,877	0	4,111
3	0	0	25	0	0	0	0	0	0	0	0	25
4	0	28	0	0	0	0	0	0	0	131	0	159
5	0	0	0	0	0	0	0	0	0	22	0	22
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	472	0	472
9	317	538	0	0	0	0	0	0	108	1	0	964
10	332	1,112	0	121	13	2	0	171	4	0	0	1,755
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	649	1,875	25	121	13	2	0	171	154	4,737	0	7,757

CONDENSED9999

DOD CONTROLLED CARGO

1969

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	0	0	0	0	0	0	0	0	0	35,551	0	35,551
2	0	0	0	0	0	0	0	0	0	120,474	0	120,474
3	0	0	0	0	0	0	0	0	0	10,299	0	10,299
4	0	0	0	0	0	0	0	0	0	9,729	0	9,729
5	0	0	0	0	0	0	0	0	0	24,258	0	24,258
6	0	0	0	0	0	0	0	0	0	708	0	708
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	80,767	0	80,767
9	0	0	0	0	0	0	0	0	0	114	0	114
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	0	0	0	0	0	0	0	0	0	281,900	0	281,900

1970

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	0	0	0	0	0	0	0	0	0	65,092	0	65,092
2	0	0	0	0	0	0	0	0	0	113,540	0	113,540
3	0	0	0	0	0	0	0	0	0	5,021	0	5,021
4	0	0	0	0	0	0	0	0	0	26,572	0	26,572
5	0	0	0	0	0	0	0	0	0	27,332	0	27,332
6	0	0	0	0	0	0	0	0	0	421	0	421
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	80,211	0	80,211
9	0	0	0	0	0	0	0	0	0	173	0	173
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	0	0	0	0	0	0	0	0	0	318,362	0	318,362

1971

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	0	0	0	0	0	0	0	0	0	67,496	0	67,496
2	0	0	0	0	0	0	0	0	0	86,605	0	86,605
3	0	0	0	0	0	0	0	0	0	2,810	0	2,810
4	0	0	0	0	0	0	0	0	0	35,752	0	35,752
5	0	0	0	0	0	0	0	0	0	21,057	0	21,057
6	0	0	0	0	0	0	0	0	0	1,157	0	1,157
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	74,842	0	74,842
9	0	0	0	0	0	0	0	0	0	12	0	12
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	0	0	0	0	0	0	0	0	0	289,731	0	289,731

1972

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	0	0	0	0	0	0	0	0	0	49,756	0	49,756
2	0	0	0	0	0	0	0	0	0	110,175	0	110,175
3	0	0	0	0	0	0	0	0	0	2,741	0	2,741
4	0	0	0	0	0	0	0	0	0	16,814	0	16,814
5	0	0	0	0	0	0	0	0	0	22,616	0	22,616
6	0	0	0	0	0	0	0	0	0	124	0	124
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	51,195	0	51,195
9	0	0	0	0	0	0	0	0	0	24	0	24
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	0	0	0	0	0	0	0	0	0	253,445	0	253,445

1973

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	0	0	0	0	0	0	0	0	0	74,720	0	74,720
2	0	0	0	0	0	0	0	0	0	66,392	0	66,392
3	0	0	0	0	0	0	0	0	0	46	0	46
4	0	[illegible]	0	0	0	0	0	0	0	20,207	0	20,207
5	0	[illegible]	[illegible]	0	0	0	0	0	0	28,148	0	28,148
6	0	[illegible]	[illegible]	0	0	0	0	0	0	29	0	29
7	0	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0
8	0	[illegible]	[illegible]	0	0	0	0	0	0	31,622	0	31,622
9	0	[illegible]	[illegible]	0	0	0	0	0	0	1,558	0	1,558
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	0	0	0	0	0	0	0	0	0	222,722	0	222,722

1974

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	0	0	0	0	0	0	0	0	0	75,483	0	75,483
2	0	0	0	0	0	0	0	0	0	58,773	0	58,773
3	0	0	0	0	0	0	0	0	0	42	0	42
4	0	0	0	0	0	0	0	0	0	14,418	0	14,418
5	0	0	0	0	0	0	0	0	0	15,075	0	15,075
6	0	0	0	0	0	0	0	0	0	3	0	3
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	43,269	0	43,269
9	0	0	0	0	0	0	0	0	0	3,400	0	3,400
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	0	0	0	0	0	0	0	0	0	210,463	0	210,463

1975

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	0	0	0	0	0	0	0	0	0	89,559	0	89,559
2	0	0	0	0	0	0	0	0	0	100,072	0	100,072
3	0	0	0	0	0	0	0	0	0	10,024	0	10,024
4	0	0	0	0	0	0	0	0	0	12,809	0	12,809
5	0	0	0	0	0	0	0	0	0	16,838	0	16,838
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	41,948	0	41,948
9	0	0	0	0	0	0	0	0	0	37	0	37
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	0	0	0	0	0	0	0	0	0	271,287	0	271,287

1976

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	0	0	0	0	0	0	0	0	0	60,024	0	60,024
2	0	0	0	0	0	0	0	0	0	104,477	0	104,477
3	0	0	0	0	0	0	0	0	0	11,946	0	11,946
4	0	0	0	0	0	0	0	0	0	9,278	0	9,278
5	0	0	0	0	0	0	0	0	0	11,435	0	11,435
6	0	0	0	0	0	0	0	0	0	39	0	39
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	25,092	0	25,092
9	0	0	0	0	0	0	0	0	0	13	0	13
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	0	0	0	0	0	0	0	0	0	222,304	0	222,304

1977

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	0	0	0	0	0	0	0	0	0	57,864	0	57,864
2	0	0	0	0	0	0	0	0	0	93,285	0	93,285
3	0	0	0	0	0	0	0	0	0	8,627	0	8,627
4	0	0	0	0	0	0	0	0	0	21,751	0	21,751
5	0	0	0	0	0	0	0	0	0	25,459	0	25,459
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	32,894	0	32,894
9	0	0	0	0	0	0	0	0	0	6	0	6
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	0	0	0	0	0	0	0	0	0	239,886	0	239,886

CONDENSED3721

AIRCRAFT AND PARTS

1969

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	74	27	0	0	0	0	0	0	0	379	0	480
2	0	281	0	0	0	0	0	0	14	5,857	0	6,072
3	0	0	4,109	0	0	0	0	0	0	79	0	4,188
4	0	3	0	3	0	0	0	0	0	376	0	382
5	0	0	0	0	0	0	0	0	0	1,027	0	1,027
6	0	0	0	0	0	0	0	0	0	22	0	22
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	1,273	1,193	2,622	0	5,088
9	19	1	0	0	4	0	0	2,463	50	0	0	2,537
10	307	296	4	406	99	0	0	272	7	0	0	1,399
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	400	528	4,113	409	103	0	0	4,008	1,264	10,362	0	21,195

1970

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	81	42	0	0	0	0	0	0	1	247	0	371
2	79	117	0	0	0	0	0	0	63	7,895	0	8,154
3	0	0	3	0	0	0	0	0	0	40	0	43
4	0	0	0	0	0	0	0	0	0	433	0	433
5	0	0	0	0	0	0	300	0	0	972	0	1,272
6	0	0	0	0	0	0	0	0	0	14	0	14
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	2,505	2,499	2,267	0	7,271
9	2	0	0	0	0	0	0	499	40	6	0	547
10	324	310	7	543	0	3	0	681	11	0	0	1,879
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	486	469	10	543	0	3	300	3,685	2,614	11,874	0	19,984

1971

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	75	79	0	0	5	0	0	0	3	574	0	736
2	49	52	0	81	0	0	0	0	6	7,604	0	7,792
3	0	0	689	0	0	0	0	0	0	174	0	863
4	0	143	0	0	0	0	0	0	1	508	0	652
5	0	0	0	0	0	0	0	0	0	837	0	837
6	0	0	0	0	0	0	0	0	0	93	0	93
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	537	1,036	2,205	0	3,778
9	2	0	0	0	0	0	0	542	35	0	0	579
10	206	475	34	120	1	1	0	278	5	0	0	1,121
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	332	750	723	201	6	1	0	1,357	1,086	11,995	0	19,454

1972

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	37	256	0	0	0	0	0	0	4	278	0	575
2	124	204	0	37	0	0	0	0	3	7,827	0	8,195
3	0	0	0	0	0	0	0	0	0	64	0	64
4	0	0	0	60	0	0	0	0	2	218	0	280
5	0	0	0	0	0	18	0	0	0	602	0	620
6	0	0	2	0	0	0	0	0	0	10	0	12
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	1,144	2,751	3,491	0	7,386
9	3	2	0	0	0	0	0	899	38	2	0	944
10	281	780	31	36	22	2	0	1,852	16	0	0	3,020
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	445	1,242	33	133	22	20	0	3,895	2,814	12,492	0	28,796

1973

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	0	188	0	0	0	0	0	0	13	630	0	831
2	71	32	0	22	0	0	0	0	1	7,184	0	7,310
3	0	0	1	0	0	0	0	0	0	23	0	24
4	0	0	0	92	0	0	0	0	0	559	0	651
5	0	0	0	0	0	0	0	0	0	830	0	830
6	0	0	0	0	0	0	0	0	0	72	0	72
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	9	0	0	0	0	0	1,393	37	2,726	0	4,165
9	33	1	0	0	0	0	0	100	53	3	0	190
10	352	727	27	32	20	1	0	2,104	0	0	0	3,263
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	456	957	28	146	20	1	0	3,597	104	12,027	0	17,336

1974

	1	2	3	4	5			8	9	10	11	SUM
1	11	236	0	0	0	0	0	0	4	1,041	0	1,292
2	38	88	0	18	0	0	0	0	2	8,631	0	8,777
3	0	0	0	0	0	0	0	0	0	28	0	28
4	0	0	0	0	0	0	0	0	0	938	0	938
5	0	0	0	0	0	0	0	0	0	1,482	0	1,482
6	0	0	0	0	0	0	0	0	0	40	0	40
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	1,093	41	4,114	0	5,248
9	5	0	0	0	0	0	0	5	15	3	0	28
10	279	993	0	53	2	1	0	1,890	0	0	0	3,218
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	333	1,317	0	71	2	1	0	2,988	62	16,277	0	21,051

1975

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	33	39	0	0	0	0	0	0	2	2,060	0	2,134
2	5	83	0	5	0	0	0	0	5	10,446	0	10,554
3	0	0	0	0	0	0	0	0	0	1	0	1
4	0	5	0	0	0	0	0	0	4	1,721	0	1,730
5	12	0	0	0	0	0	0	0	0	879	0	891
6	0	0	0	0	0	0	0	0	0	5	0	5
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	363	60	3,471	0	4,244
9	0	0	0	0	0	0	0	5	2	11	0	18
10	337	927	1	62	24	0	0	1,173	26	0	0	2,550
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	387	1,054	1	67	24	0	0	1,549	99	18,396	0	21,577

1976

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	15	29	0	0	0	0	0	0	1	1,082	0	1,127
2	25	187	0	0	0	0	0	0	4	8,458	0	8,667
3	0	0	0	0	0	0	0	0	0	5	0	5
4	0	10	0	0	0	0	0	0	0	1,227	0	1,241
5	1,300	0	0	0	0	0	0	0	0	935	0	2,235
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	264	52	4,710	0	5,026
9	0	0	0	0	0	0	0	0	22	1	0	23
10	159	898	2	78	5	1	0	706	1	0	0	1,846
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	1,500	1,124	2	78	5	1	0	970	80	16,414	0	20,174

1977

	1	2	3	4	5	6	7	8	9	10	11	SUM
1	10	202	0	0	0	0	0	0	0	1,053	0	1,265
2	126	256	0	0	0	0	0	0	7	5,662	0	6,051
3	0	0	0	0	0	0	0	0	0	31	0	31
4	0	0	0	0	0	0	0	0	0	1,078	0	1,078
5	0	0	0	0	0	0	0	0	0	880	0	880
6	0	0	0	0	0	0	0	0	0	2	0	2
7	0	0	0	0	0	0	0	0	0	0	0	0
8	20	0	0	0	0	0	0	374	100	5,442	0	5,936
9	3	0	0	0	0	0	0	132	10	0	0	145
10	91	859	31	50	1	1	0	1,251	1	0	0	2,285
11	0	0	0	0	0	0	0	0	0	0	0	0
SUM	250	1,317	31	50	1	1	0	1,757	118	14,148	0	17,673

APPENDIX C

CORPS OF ENGINEERS REVIEW OF THE IMPACTS ON NAVIGATION FROM THE MOUNT ST. HELENS ERUPTION

The National Waterways Study was authorized by Congress in Section 158 of the Water Resources Development Act of 1976. Clearly stated in the authorization language is the phrase, "...The study shall include a review of the existing system and its capability for meeting the national needs, including emergency and defense requirements..."

This aspect of the study mandate subsequently proved to be prophetic with the 18 May 1980 eruption of Mount St. Helens in southwestern Washington state. This calamitous event - one not likely to be envisioned in even the broadest spectrum of waterway emergency planning - led to massive amounts of runoff of mud and debris into the Toutle Basin, the Cowlitz River, and ultimately into the Columbia River at the Longview-Kelso port complex (river mile 68.0). According to Portland District estimates, 40 to 55 million cubic yards of volcanic ash, sand and gravel flowed down the Toutle and Cowlitz Rivers to form a 25-foot-high mound across portions of a 9.5-mile stretch of the Columbia River navigation channel. By comparison, annual dredging of the Columbia below Portland, including the mouth, generally yields 10 to 11 million cubic yards of material.

The actions subsequently taken unilaterally by the Corps as well as in cooperation with other agencies, provides a useful case study of Corps' response to an unanticipated emergency situation on a waterway. The sequence of events initiated to reopen the clogged Columbia to shipping provides input for comparison with the theoretical guidelines used in the defense and emergency component of the National Waterways Study.

Ascertaining the magnitude of the shoaling after the initial eruption, the North Pacific Division and the Portland District offices responded quickly and efficiently, summoning Corps hopper dredges along the West Coast for emergency round-the-clock dredging. Further aided by private industry dredges contracted by the Corps, the hastily organized dredging team succeeded in opening

a temporary navigation channel of 25 x 200 feet within the original 40 x 600 foot channel by 28 May. With support from the Coast Guard, shipping resumed using twice daily high tide "windows," helping to ease the estimated $5 million per day losses suffered as a result of closure of the lower Columbia. By 14 June the allowed vessel draft was increased to 36 feet 11 inches and the last of the ships trapped by the massive shoaling slowly churned through the temporary channel, drawing an uneasy 36 feet of water. Full restoration of the 40 x 600 foot normal navigation channel is a four-to-five-month continuous dredging project.

The ultimte economic costs of such a natural disaster are staggering. The Corps estimates over $219 million is needed to repair or replace just water-related structures or facilities in the affected rivers. A year or more may be needed to complete the necessary dredging to restore the navigation and floodplain areas of the Columbia and Cowlitz to their approximate original states.

The lesson of Mount St. Helens helps to illustrate the importance of the NWS defense and emergency element. Highlighting Corps response time, costs involved and funding sources, interagency cooperation, and other aspects of a waterway-related emergency, this event provides useful points for comparison with the corresponding component of the National Waterways Study.